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REPORT ON THE EFFECT OF THE ST. LOUIS METROPOLITAN AREA ON WATER QUALITY IN THE MISSISSIPPI RIVER, DECEMBER 1969

National Field Investigations Center
Cincinnati, Ohio

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DECEMBER 1969

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Conclusions

1. Phenols discharged in the St. Louis area constitute a violation of the Missouri water quality standards and the proposed Illinois water quality standards which prohibit the discharge of materials that cause tainting of fish flesh. Phenol concentrations downstream from St. Louis are substantially higher than upstream phenol concentrations. The average phenol concentration found above river mile 177.0 was 1.7 ug/l. Below river mile 177.0 concentrations reached a high of 374 ug/l in one sample and averaged 23.0 ug/l on the Missouri side and 9.8 ug/l on the Illinois side.

2. Phenols discharged in the St. Louis area were detected 67 miles downstream at Chester, Illinois and the Menard Prison at levels which exceed the 1962 Public Health Service Drinking Water Standards (1 ug/l) and the State of Missouri published water quality objectives for the Mississippi River (average 2 ug/l). Phenol concentrations averaged 7.2 ug/l on the river cross section at Chester, Illinois (river mile 109.7).

3. Phenols discharged in the St. Louis area are a probable cause of the tastes and odors at the Chester, Illinois and Menard Prison water intakes, which require the use of break point chlorination to control tastes and odors.

4. The fishery in the Mississippi River in the 67 miles between St. Louis and Chester, Illinois has been severely damaged by wastes from the St. Louis area and has lost most of its economic value. The

sale of fish from the area downstream from St. Louis is nearly non-existent because of tainted fish flesh.

5. Fecal coliform counts in the Missouri River at the sampling point 7.4 miles from its mouth and in the Mississippi River between the confluence with the Missouri River and at least as far as 85 miles downstream to Chester, Illinois, constitute a violation of the Missouri water quality standards which require a maximum of no more than 2000 per 100 ml. This was violated by 37% of the samples taken at Chester.

6. The pathogens found in the Mississippi River as far as 37 miles downstream from the St. Louis metropolitan area constitute a health hazard. Eleven serotypes of Salmonella were isolated from the stream or effluent discharging to the stream including S. paratyphi B. odense, causative agent of paratyphoid fever in humans.

7. The pesticide content of the Mississippi River in the entire study area, both above and below St. Louis is high and violates the water quality standards which prohibit substances toxic to humans, fish and wildlife. The concentration of DDT at one point approached the 48-hour median tolerance limit for Daphnia.

8. The River Des Peres, tributary to the Mississippi in the St. Louis area, is grossly polluted. The phenol concentration in the water averaged 11.2 ug/l. Volatile solids, COD, phosphorus, ammonia, organic nitrogen, phenol, arsenic, sulfide, iron, barium

and manganese concentrations in the sediments are very high. Industrial discharges are the primary source of these wastes.

9. The waters of the Meramec and the Kaskaskia Rivers were relatively unpolluted at the time they were sampled, but sampling of bottom-dwelling organisms indicate that these rivers are affected by occasional periods of pollution, probably during run-off periods.

10. The National Lead Company discharges a large volumes of untreated industrial wastes to the Mississippi River containing very high concentrations of solids, acids, arsenic, sulfate, iron and toxic metals. Arsenic discharged from the National Lead Company accumulated in the Mississippi River-bed sediments for at least 5.8 miles downstream. Concentrations upstream from National Lead Company were 2.3 mg/kg of sediment but downstream concentrations as high as 96.4 mg/kg were present. Iron precipitates accumulated on the natural river bottom of the Mississippi for at least 5.8 miles restrict the growth of natural flora and fauna for at least 3.8 miles downstream from the National Lead Company. The National Lead Company has not complied with the recommendations of the Conference on Pollution of Interstate Waters of the Mississippi River-St. Louis Metropolitan Area held on March 4, 1958.

11. Pollution has caused a drastic reduction in quantity of desirable attached algal growths that contribute to fish food and oxygen production, and an increase in growths of undesirable slime organisms

in at least 23 miles of the Mississippi River downstream from the confluence of the Chain of Rocks Canal to the confluence of the Meramec River.

12. Floating organic solids, such as fecal material and packing-house wastes, make the Mississippi River aesthetically objectionable, restrict recreational development of the river and create a potential health hazard in at least 43 miles of river downstream from the confluence of the Chain of Rocks Canal to approximately 10 miles downstream from Crystal City, Missouri.

13. The presence of extensive oil slicks interfere with recreational boating, is aesthetically objectionable and may be indicative of wastes that impart objectionable tastes and odors to fish in at least 23 miles of the Mississippi River downstream from the confluence of the Chain of Rocks Canal to the confluence of the Meramec River.

INTRODUCTION

Water quality standards have recently been established by the State of Missouri for the Mississippi River in order to protect and enhance the quality of the water and to insure that it will be suitable for desirable uses, present and future. The State of Illinois has proposed water quality standards for the Mississippi River but these have not been approved by the Secretary of the Interior. This study was undertaken to determine if present water quality standards are being met.

The Mississippi River, an interstate stream dividing the states of Missouri and Illinois, serves the St. Louis-East St. Louis metropolitan area and points downstream as a principal source of water supply. It is also a major transportation artery, providing extensive commercial and recreational fishing and is used for recreational purposes in many areas. The utilization of this resource for the various functions which it is capable of fulfilling depends on the quality of its waters. The quality of these waters will be an important factor in the future economy of the area. The expanding population and industrial activity in the area are putting greater and greater pollutional loads into the river. The enhancement of the quality of the river's waters can only be assured by controlling the discharge of municipal, industrial and agricultural wastes to the river.

The Metropolitan St. Louis Sewer District (MSSD) had previously conducted a year long water quality study in the area with financial assistance from the the Federal Water Pollution Control Administration. The results of the MSSD study were used extensively in the design of this study. The Federal study does not duplicate the MSSD study but was undertaken to verify and supplement it.

The MSSD study indicated that the most severe water quality problems in the river are bacterial contamination, tainted fish and tastes and odors in water supplies. The Federal study concentrated on these problems with an intensive twelve-day sampling program. Samples were collected and analysed for indicator bacteria, pathogenic bacteria, phenol, pesticides, benthic biology, phytoplankton and bottom sediment chemistry. The outfalls of the National Lead Company of St. Louis were also sampled.

Description of River Reach

The area of interest starts at Lock and Dam No. 26 at Alton, Illinois (River Mile 202.7) and extends downstream to the water intake at Chester, Illinois (River Mile 109.7). The major tributaries within this reach are the Missouri River which meets the Mississippi at Mile 195.3, the River Des Peres (River Mile 171.9), the Meramec River (River Mile 160.7) and the Kaskaskia River (River Mile 118.1).

The major population concentration along this reach is in the City of St. Louis on the Missouri side. The total population of the St. Louis metropolitan area is approximately 2.4 million.(1)

The St. Louis area is heavily industrialized and well diversified. The industries include meat packing plants, dairies, textile and paper mills, chemical producers, metal processing plants, breweries, grain processors and automotive plants to name a few. About 75 percent of the industry in the area is located in Metropolitan St. Louis. The MSSD estimates the population equivalent of the industrial wastes to be about 4 million so that the total population equivalent is 6.4 million.(1)

The reach serves as the raw water source for several industries and communities including St. Louis, Mo., East St. Louis, Illinois, Chester, Illinois and the Menard State Prison in Chester, Illinois. Industries using river water include the Illinois Power Company, the Olin Mathieson Chemical Company, Union Electric Company, Anheuser-Busch brewery, and National Lead Company. The St. Louis and East St. Louis intakes are located upstream from the metropolitan area. The Chester and Menard State Prison intakes are approximately 50 miles below the metropolitan area. The time of water travel from the metropolitan area to these intakes is about one day during high flow and one and one-half days during low flow condition.(1) Break point chlorination is necessary to control taste and odor problems at these intakes.

The St. Louis MSSD did extensive dye studies to determine the flow characteristics of the river. The average discharge between December 1, 1969 and December 12, 1969 was 115,000 cfs at St. Louis. Estimated times of travel at this flow from river mile 184 based on Figure 14 of the St. Louis MSSD report are: RM 169 - 6 hours, RM 140.1 - 17 hours and RM 109.7 (Chester) - 32 hours.

The first use to be affected by pollution in a body of water is the fishery. In 1954 the Bi-State Development agency estimated that the fishery in the Mississippi River below St. Louis was reduced by 80%.(4) The MSSD reports further declines since 1960 at a rate of 7,000 pounds of fish caught per year. The sale of commercial fish is now practically non-existent from St. Louis to Cape Girardeau. The reason is not a lack of fish but tastes and odors associated with fish from this reach.(1)

Phenol

Phenol and phenolic compounds such as cresol and xylenol are found in wastes from the distillation of wood, gas works, coke ovens, oil refineries and chemical plants. These compounds are known to cause tastes and odors in water and to taint the flesh of fish. The California Water Quality Control Board has reported that threshhold concentrations for taste and odor have occurred between 10 ug/l and 100 ug/l in raw water supplies. In chlorinated water, these threshhold concentrations have been reported between 0.1 ug/l and 1 ug/l. Fish flesh has been tainted by concentrations of 20 ug/l to 150 ug/l in polluted river water and concentrations of 500 ug/l have been reported as lethal or damaging to fish in river water.(2)

The Public Health Service's 1962 Drinking Water Standards recommend a limit of 1 ug/l in water used for public consumption.(5) The Illinois and Missouri water quality standards do not establish a limit for phenol although the State of Missouri has published water quality objectives which call for a maximum of 5 ug/l at any point after initial dilution and a monthly average of not more than 2 ug/l at any point in the Mississippi River.(3) The standards limit taste and odor producing substances to "concentrations in the stream that will not interfere with the production of potable water by reasonable water treatment processes, or impart unpalatable flavor to food fish, or result in noticeable offensive odors in the vicinity of the water, or otherwise interfere with the reasonable use of the water."

The St. Louis Metropolitan Sanitary District reports that phenolic compounds are found in considerable quantity in the effluents from industries in St. Louis and East St. Louis. The major sources of phenol in the area are from chemical manufacturing plants and oil refineries.(1)

In the present study, phenol samples were collected from 16 transects on the Mississippi River, one transect each on the Missouri River, the Kaskaskia River, the Meramec River and the Des Peres, on every second day of the study so that there are 5 or 6 samples from each station on each transect. Samples were also collected from two transects upstream from the Alton Lock and Dam on December 10, 1969. (See Figure 1) All samples were preserved with sodium hydroxide to a pH of 11.0, and sent to the Lake Michigan Basin Office for analysis within 48 hours of collection.

The average results for each station are given in Table 1 and plotted on Figure 2, page 15. The data indicate a very severe source of phenol on the Missouri side between river mile 183.5 and river mile 177. A concentration of 374 ug/l phenol was found at station 177A on December 11, 1969. This heavy pollution was reflected downstream by concentrations of 276 ug/l at 173A, 232 ug/l at 169A. A lesser source located in East St. Louis above river mile 177 is also indicated. Figure 2 shows that the phenolic compounds in the

river tend to flow along the shorelines and are not completely mixed across the river until river mile 129. The average concentration of 7.2 ug/l found at Chester near public water intakes exceeds the Public Health Service recommendation of 1 ug/l for water supplies and the State of Missouri's water quality objective of an average of 2 ug/l.

Relatively little phenol was found upstream from river mile 177.0. None was found in 20 samples taken at river mile 7.4 on the Missouri River. An overall average of 1.7 ug/l was found in the Mississippi River transect above river mile 177.0. Downstream from river mile 177.0 phenol concentrations averaged 23.0 ug/l on the Missouri side and 9.8 ug/l on the Illinois side.

The MSSD reports that, during 1968, 1,179 pounds of fish were caught per mile of river in the 201 miles above the Chain of Rocks dam and 350 pounds of fish per mile were caught in the 135 miles below the dam. They also report that the sale of commercial fish is practically non-existent between St. Louis and Cape Girardeau, Missouri. The reason for this was stated as tastes and odors in fish rather than lack of fish.(1)

Conclusion number 8 of the MSSD report states "A definite relationship exists between phenol concentrations and the occurrence of taste and odor problems in water supplies located on the east bank of the Mississippi River."

The possibility that substantial quantities of phenolic materials might be reaching the rivers from natural sources was investigated by collecting samples from streams believed to be unaffected by industrial wastes. These samples were sent to the Analytical Quality Control

Laboratory, Division of Water Quality Research in Cincinnati, Ohio for analysis by Thin Layer Chromatography. This method is not specifically designed to determine naturally occurring phenols but extracts of several natural materials do give positive response to the detecting agents.(6)

The samples were from mile point 211.0 on the Mississippi (a composite across the river), the Cuivre River at Old Monroe, Missouri and the Meramec River at mile point 22. No natural phenolic materials were detected. They were estimated, if present, to be less than 1 ug/l. The total phenol measured by the standard FWPCA method(7) in Chicago was 2.2 ug/l on the Mississippi River sample and 1 ug/l in the Meramec River sample. It is concluded that naturally occurring phenols were not significant during this study.

The present discharges of phenol and phenolic materials in the St. Louis and East St. Louis area are clear violations of the water quality standard prohibiting the discharge of substance that impart unpalatable flavor to food fish. (Missouri Water Quality Standards - Mississippi River, Zone 2, paragraph f.) (Illinois Sanitary Water Board, Rules and Regulations SWB-13, Article II, Rule 2. 04, paragraph 5.)

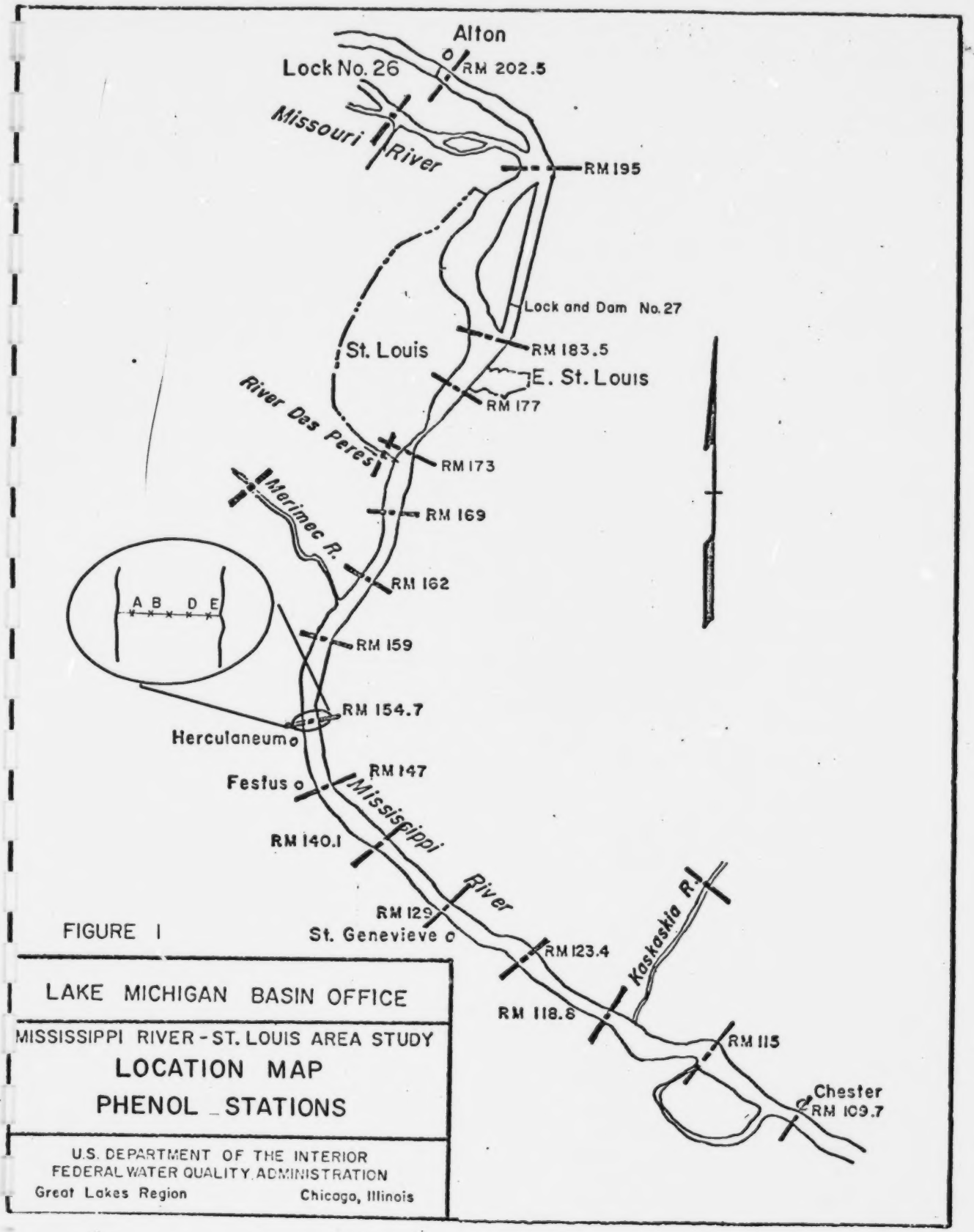


FIGURE 1

LAKE MICHIGAN BASIN OFFICE

MISSISSIPPI RIVER - ST. LOUIS AREA STUDY

LOCATION MAP

PHENOL _ STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
Great Lakes Region Chicago, Illinois

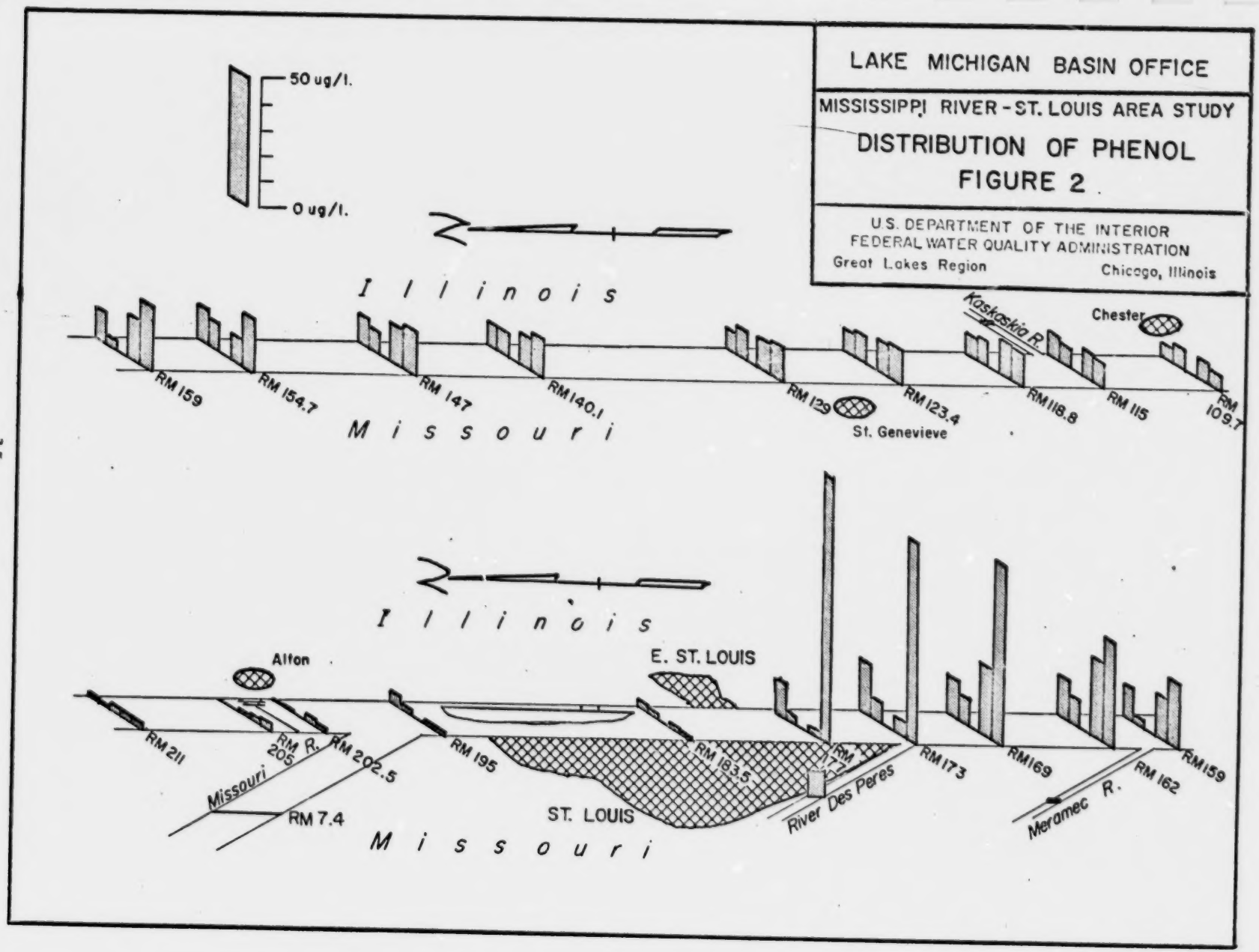
TABLE 1

Average Concentrations of Phenol (ug/l)

Station	Missouri side A	B	C	Illinois side D	E
Missouri 7.4	NF	NF		NF	NF
Miss. 211.0	3*	3*	3*	1*	2*
Miss. 205.0	4*	3*	2*	NF*	NF*
Miss. 202.5	1.6	2.4		1.0	0.6
Miss. 195.0	0.4	0.4		1.6	4.6
Miss. 183.5	1.8	2.0		2.6	3.0
Miss. 177.0	101.4	1.6		1.6	12.0
Miss. 173.0	76.3	6.7		8.5	20.0
Miss. 169.0	69.5	27.8		9.8	14.3
Miss. 162.0	39.0	30.0		10.8	16.0
Miss. 159.0	25.5	16.5		3.7	12.2
Miss. 154.7	20.8	9.8		10.7	13.0
Miss. 147.0	17.8	15.0		9.0	11.8
Miss. 140.1	15.5	12.0		9.5	9.5
Miss. 129.0	13.8	11.8		8.7	8.5
Miss. 123.4	13.7	12.8		10.5	8.5
Miss. 118.8	12.5	12.8		8.7	8.2
Miss. 115.0	9.5	10.8		7.4	9.5
Miss. 109.7	7.7	8.5		7.2	5.5
River Des Peres 1.0			11.2		
Meramec River 6.9			1.7		
Kaskaskia River 4.5			1.4		

*Based on one sample only

NF - None detected within sensitivity of test.


LAKE MICHIGAN BASIN OFFICE
MISSISSIPPI RIVER - ST. LOUIS AREA STUDY
DISTRIBUTION OF PHENOL
FIGURE 2
U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
Great Lakes Region
Chicago, Illinois
50 ug/l.
0 ug/l.
N
Illinois
Missouri
RM 159
RM 154.7
RM 147
RM 140.1
RM 129
St. Genevieve
RM 123.4
Kaskaskia R.
RM 118.8
RM 115
Chester
RM 109.7
Alton
RM 211
RM 205
RM R.
Missouri
RM 202.5
RM 195
RM 7.4
E. ST. LOUIS
RM 183.5
RM 177
ST. LOUIS
River Des Peres
RM 173
RM 169
Meramec R.
RM 162
RM 159

Microbiology

The purpose of testing water for bacteria is to detect the presence of microbes that may be pathogenic to man or animals. The direct search for the presence of a specific pathogen is too expensive and unwieldy for routine testing purposes. Instead, the water is examined for indications of fecal contamination and, when such indications are found, the water is assumed to be potentially dangerous.

The group of bacteria known as coliforms has been selected as suitable indicators because they inhabit the intestinal tract of warm blooded animals. The presence of coliforms does not necessarily indicate fecal contamination because some forms persist in soil and other environments. Other indicator organisms are fecal streptococci, which are abundant in the intestinal tracts of warm blooded animals. These organisms do not ordinarily multiply in surface waters and are rarely found in soil or on vegetation not contaminated by sewage.

The standards established by the State of Missouri require that "The fecal coliform, in water designated for drinking water supply, boating and canoeing, and/or fishing, shall not exceed 2000/100 ml (either MPN or MF count) except in specified mixing zones adjacent to or downstream from waste outfalls."

Samples were collected at 10 Mississippi River transects, the Missouri transect, and the River Des Peres, Meramec River and

Kaskaskia River sampling points on each day of the study so that 11 or 12 values are available from each point. See Figure 3. Each transect was sampled at points, A, C and E so that the coliform distribution across the stream could be determined. All samples were taken to the FWPCA mobile laboratory at Kimmswick, Missouri and processed within six hours of collection.

The average results of these analyses are presented in Table 2. These results indicate that during the twelve days of the study, the Missouri River was contaminated (36% violations of standards), the Mississippi River above the confluence with the Missouri was relatively clean, the Mississippi River at St. Louis and immediately below was more contaminated than the Missouri (73% violations of standards between RM 183.5 and RM 140.1), the Mississippi River at Chester was contaminate (37% violations) and the Missouri side of the river was more contaminated than the Illinois side upstream from river mile 140.1.

Bacterial survival tests were also run on samples from selected transects. See Figure 3. Total coliform, fecal coliform, and fecal streptococcus counts were determined on the water as collected and incubated for two, three, and seven days at the average temperature of the stream when sampled, utilizing 900 ml test portions.

Initial counts (Day 0) were made at the mobile laboratory in Kimmswick, and subsequent determinations were performed in the microbiology laboratory at the Lake Michigan Basin Office.

The purpose of this test is to determine if there are any substances, such as nutrients, present in the water that would cause the bacteria to multiply or any toxic materials that might kill them. The results, presented in Table 3, indicate no evidence of such substances since the dieoff rates appear to be normal.

In order to detect the presence of pathogenic organisms, 16 Moore Gauze pads for the isolation of salmonella were placed in the stream and two in the effluent of the Lemay Sewage Treatment Plant (Figure 3). The genus Salmonella is responsible for some of the most severe diseases in man, including typhoid fever and paratyphoid fever. All species of Salmonella are considered pathogenic to man, usually causing enteric disorders. Twelve of the 16 pads placed in the Mississippi River were recovered. Table 4 shows that 9 of the 10 pads taken from the river were positive for Salmonella. The two pads recovered from the Lemay sewage treatment plant effluent were also positive. Forty-three isolated cultures were serotyped to identify species by the Communicable Disease Center at Atlanta, Georgia. The 11 different serotypes detected are shown in Table 4.

Table 4 shows that Salmonella were detected as far south as river mile 139.5. S. oranienburg was isolated from the Lemay sewage treatment plant outfall and also from pads placed 3.1 miles downstream, 13.5 miles downstream and 32.2 miles downstream. This may indicate that Salmonella organisms were transported this distance in the stream. S. paratyphi-B. was

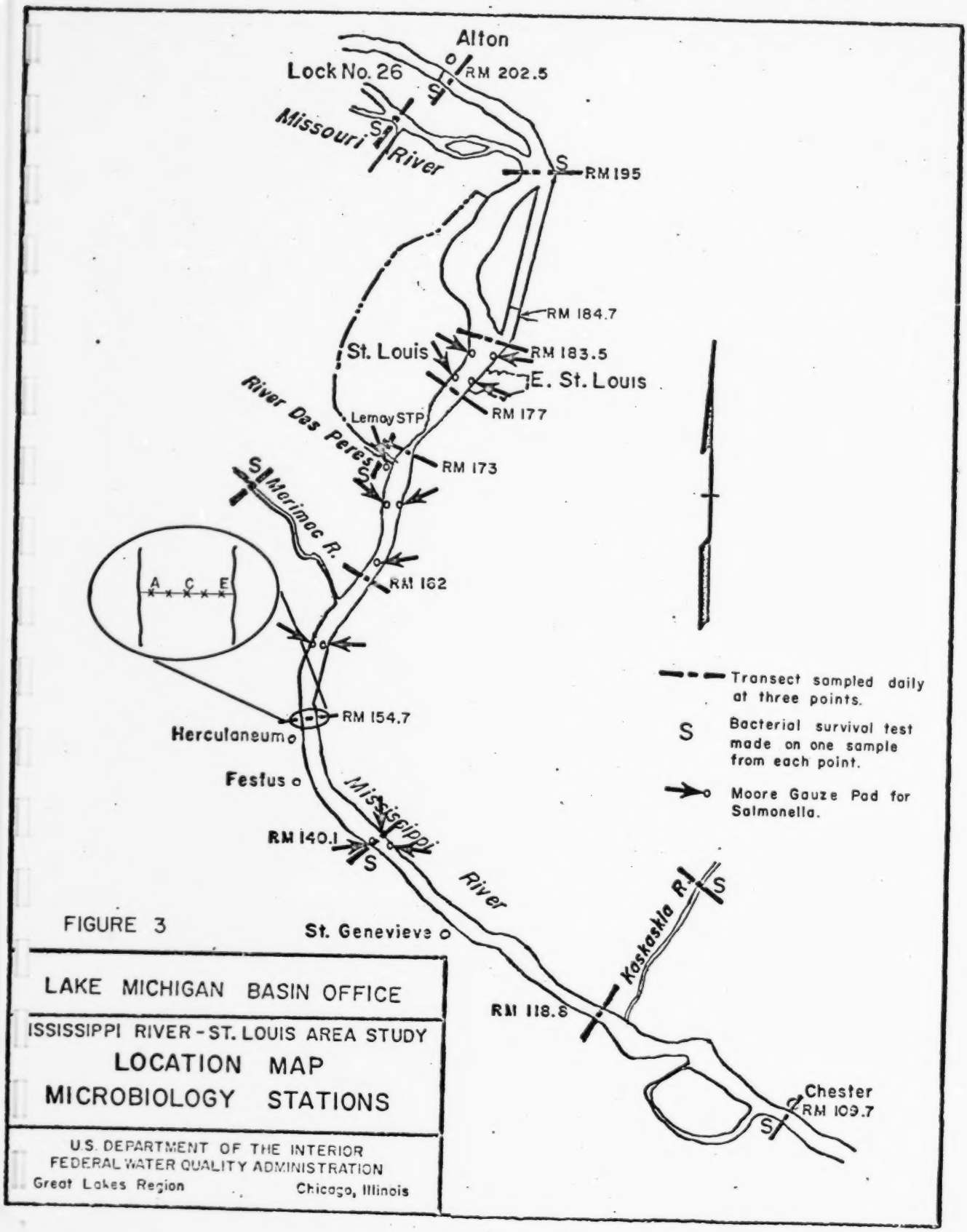


FIGURE 3

LAKE MICHIGAN BASIN OFFICE

ISSISSIPPI RIVER - ST. LOUIS AREA STUDY

LOCATION MAP

MICROBIOLOGY STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
Great Lakes Region Chicago, Illinois

Table 2

Arithmetic Averages* of Microbiological Results
with Percent of Violations of Missouri Standard

Station		Total Coliform Per 100 ml	Fecal Coliform Per 100 ml	% Violation	Fecal Streptococci Per 100 ml
Missouri	7.4 A	53,000	1,670	27%	3,680
Missouri	7.4 C	47,600	2,100	54%	3,700
Missouri	7.4 E	50,700	1,740	27%	3,740
Miss.	202.5 A	700	94	0%	28
Miss.	202.5 C	915	56	0%	39
Miss.	202.5 E	1,400	185	0%	103
Miss.	195.0 A	54,400	2,040	45%	3,400
Miss.	195.0 C	49,000	1,620	36%	3,800
Miss.	195.0 E	16,600	1,360	27%	1,890
Miss.	183.5 A	65,900	3,600	82%	5,730
Miss.	183.5 C	28,300	2,330	18%	3,200
Miss.	183.5 E	49,200	3,830	100%	17,770
Miss.	177.0 A	73,400	7,780	90%	1,680
Miss.	177.0 C	40,600	1,460	10%	3,370
Miss.	177.0 E	38,700	2,540	60%	4,800
Miss.	173.0 A	63,400	4,690	91%	13,600
Miss.	173.0 C	38,400	1,860	36%	2,770
Miss.	173.0 E	40,600	3,050	91%	3,330
Miss.	162.0 A	64,600	5,580	100%	17,800
Miss.	162.0 C	53,400	2,810	58%	5,460
Miss.	162.0 E	60,300	2,980	67%	2,660
Miss.	154.7 A	68,000	4,150	100%	12,400
Miss.	154.7 C	41,700	2,750	73%	3,630
Miss.	154.7 E	42,800	2,850	91%	3,980
Miss.	140.1 A	50,800	4,480	100%	12,800
Miss.	140.1 B	61,400	4,350	100%	9,880
Miss.	140.1 C	45,200	1,840	91%	6,780
Miss.	140.1 D	38,500	2,390	63%	4,130
Miss.	140.1 E	41,300	1,780	30%	2,740

*For actual results, see Appendix

Table 2 (con't)

Station		Total Coliform Per 100 ml	Fecal Coliform Per 100 ml	% Violation	Fecal Streptococci Organisms Per 100 m
Miss.	118.8 A	35,500	2,680	82%	5,590
Miss.	118.8 C	43,000	2,950	91%	7,310
Miss.	118.8 E	33,700	1,930	50%	3,060
Miss.	109.7 A	36,200	1,960	33%	5,570
Miss.	109.7 C	35,500	2,370	58%	4,860
Miss.	109.7 E	29,600	1,470	18%	2,600
River Des Peres	1.0 C	8,700	2,620	8%	5,180
Meramec River	6.9 C	3,740	69	0%	162
Kaskaskia	4.5 C	43,400	1,140	20%	2,580

Table 3
Bacterial Survival Study

Station	Total Coliform/100 ml				Fecal Coliform/100 ml				Fecal Streptococci/100 ml			
	Day 0	Day 2	Day 3	Day 7	Day 0	Day 2	Day 3	Day 7	Day 0	Day 2	Day 3	Day 7
Missouri 7.4												
A	65,000	2,100	3,000	6,400	790	340	200	65	3,900	500	250	110
C	53,000	2,600	4,000	2,300	1,100	200	200	60	4,400	500	205	140
E	60,000	1,200	4,500	2,200	910	160	100	30	4,100	230	250	140
Miss. 202.5												
A	970	100	280	120	46	210	20	5	30	10	20	10
C	2,300	2,100	150	290	NR	30	40	25	110	10	20	5
E	2,800	300	320	140	240	10	60	15	150	70	45	20
Miss. 195.0												
A	170,000	700	600	200	990	290	200	30	3,000	380	225	110
C	49,000	2,900	5,000	1,400	820	510	200	50	3,700	210	200	120
E	9,600	1,800	1,400	300	1,200	430	190	25	220	40	125	30
Miss. 140.1												
A	54,000	21,000	100	28	4,600	1,900	1,200	390	2,600	800	480	150
B	64,000	46,000	69,000	12,000	4,100	900	760	460	320	100	240	64
C	53,000	27,000	28,000	8,000	2,800	1,200	700	130	260	100	200	80
D	59,000	26,000	20,000	11,000	2,000	200	220	184	50	220	45	76
E	41,000	18,000	30,000	3,800	1,900	1,500	1,200	390	530	200	450	200
Miss. 109.7												
A	43,000	44,000	21,000	3,000	1,500	1,500	1,200	390	530	200	450	200
C	38,000	32,000	41,000	8,100	2,900	1,700	1,500	550	650	300	750	170
E	32,000	12,000	10,000	4,200	1,400	800	700	220	350	300	210	75
River Des Peres	2,100	210	25	25	210	25	25	65	240	20	25	25
Kaskaskia River	3,500	1,200	1,000	560	370	200	220	184	50	220	45	76

also isolated from the LeMay sewage treatment plant outfall. This organism is known to cause paratyphoid fever in humans. Its presence in the river is a definite health hazard.

The results of the Salmonella survey show that the waters of the Mississippi River harbor an assortment of Salmonella serotypes. Since all Salmonella must be considered potential pathogens, their presence in the water is a hazard to anyone using the river for fishing, recreation or as a source of drinking water.

Table 4

Results of Salmonella Study

Site	Serotypes found
River mile 18.18 Missouri side	S. cubana
River mile 181.8 Illinois side	S. infantis S. heidelberg S. java
River mile 179.6 Illinois side	S. cubana
River mile 179.0 Missouri side	S. drypool S. derby
Effluent LeMay Sewage Treatment Plant (River mile 171.7) both samples	S. oranienburg S. paratyphi B. odense S. newport S. siegburg S. cubana S. infantis
River mile 168.6 Missouri side	S. oranienburg
River mile 168.6 Illinois side	S. panama
River mile 163.8 Illinois side	negative
River mile 158.2 Missouri side	S. oranienburg
River mile 158.2 Illinois side	S. oranienburg
River mile 140.1 Missouri side (2)	both negative
River mile 139.5 Illinois side	S. oranienburg S. cubana

Biology

The macro invertebrate fauna (animal life) of a river are associated with river bottoms and are therefore known as bottom organisms or benthos. The benthos play an important role in the food chain of an aquatic system. They feed primarily on microscopic plant life, inert organic material and smaller animal forms. In turn, they serve as food organisms for many species of fish and are, therefore, an essential factor in the ecology of a stream.

Benthic organisms also serve as indicators of the water quality of a stream. Each organism has requirements for its surrounding environmental conditions. Stoneflies, mayflies, and caddisflies, for instance, all require high quality water on a continuous basis and will not be found where moderate or severely polluted conditions occur. These are known as pollution intolerant forms. Other organisms such as sludgeworms and bloodworms do not require as much oxygen and thrive on the organic material present in polluted conditions. These are known as pollution tolerant organisms. Some organisms can live in both clean and polluted water, these are known as facultative organisms.

In general, clean water conditions support a large variety of organisms with pollution intolerant forms predominating. Polluted conditions usually produce very large populations of one or two pollution tolerant forms and no pollution intolerant forms. Extreme pollution may produce conditions where no life exists at all.

The nature of the river bottom is also an important factor in determining the nature of the benthic fauna. Sands which are continually being shifted and turned over by currents prevent bottom animals from

being established. This condition was encountered at many of the stations in the Mississippi River and few, if any, organisms were found at these points. The most productive areas were those where the bottom consisted of mud or silt.

Benthic biology samples were taken at five points at each of 16 Mississippi River transects (See Figure 4), one Missouri River transect, three each on the Kaskaskia and Meramec River transects and one at the River Des Peres. Each sample was collected by an aquatic biologist, screened in a No. 30 sieve, preserved with 10% formalin and returned to the laboratory for identification of the organisms. The results of this work are presented in Table 5, page 31.

Conclusions that can be drawn from the results of the regular transect sampling on the Mississippi River are fragmentary because no organisms were found at most of the stations due to the shifting sands on the river bed. The Mississippi River upstream control station at river mile 202.5 is unpolluted except near the mouth of the locks on the Illinois side, where pollution is indicated by the oil on the bottom and the 860 sludgeworms at point E. At river mileage 123.4, clean water organisms were found at four of the five points and a balanced population appears to exist. This indicates that, at this point, the river had recovered from the waste loads of the metropolitan area.

The Meramec and Kaskaskia rivers both had very moderate numbers of facultative and tolerant organisms but no intolerant organisms.

This indicates basically clean streams that are occasionally subjected to slugs of pollution, probably during periods of heavy runoff.

The bottom of the River Des Peres consisted of a white caustic material that apparently is not capable of supporting life. This is a result of industrial wastes in the stream.

A localized area of sewered pollution in the Chain of Rocks Canal below Lock and Dam No. 27 was noted and sampled. A tributary at river mile 184.7 on the Granite City Army Depot property had a strong odor of "chicken feathers" and was steaming. Samples taken above the outfall, immediately below the outfall, 300 feet below the outfall and ½ mile below the outfall produced very high concentrations of sludgeworms and other pollution tolerant species indicating severe degradation. The mild concentration of sludgeworms and mayfly larvae at Mississippi River station 183.5 E may also be a reflection of this pollution.

Biologists from the National Field Investigations Center conducted a study to determine the effects of pollution on periphyton (attached organisms) in the Mississippi River. The reach studied extended from upstream of metropolitan St. Louis, Missouri, (Lock and Dam 26) downstream to river mile 140 which is approximately 10 miles downstream from Crystal City, Missouri. Twelve sampling stations for attached growths were established along the 65-mile reach of river (Figure 5). Data for these 12 sampling stations are included in Table 6. Field investigations for this portion of the study were initiated November 16, 1969, and completed December 12, 1969.

An attached algal community serves a vital role in the aquatic environment. It provides the first link in the food chain for valuable

food and game fish. Algal photosynthesis contributes dissolved oxygen to a river. In a clean river, the community of attached algae is predominately diatoms. Increasing organic pollution causes a progressive reduction in the relative numbers of diatoms and gives rise to increasing numbers of organisms that are consumers of decaying organic material. Inorganic pollutants may be toxic and if precipitation occurs, can blanket organisms and have a smothering effect.

Downstream from the confluence of the Chain of Rocks Canal at station 183 (Figure 5), there was a drastic decrease (95 percent) in numbers of attached diatoms and a reduction (78 percent) in the quantity of chlorophyll A in the community of attached growths from the preceding upstream station (Figures 6 and 7). This condition remained essentially unchanged downstream to station 160 near the confluence of the Meramec River, a distance of 23 miles. Along this 23 mile reach of river, numerous outfalls were discharging waste waters to the river. Increased turbidity caused by finely divided suspended solids in addition to oil scum and copious quantities of floating organic solids (such as human excrement, chunks of animal fat, hair, and grain hulls) contributed to the reduction in attached algae. These materials restricted the amount of solar energy (sunlight) that penetrated the water. Sunlight is the energy needed by algal chlorophylls to produce food for nourishment, growth, and reproduction of algae. These pollutants also make the stream aesthetically objectionable and pose a potential health hazard to recreationalists. Oil

slicks are indicative of wastes that impart objectionable tastes and odors to fish flesh.

Competition and crowding by slime growths that feed on decaying organic wastes also inhibited or restricted the growth of attached diatoms. Both algae and slimes are carbonaceous and contribute to the total carbon accumulated on the slides, but since algae contain chlorophylls and slimes do not, a community of periphyton with a high carbon content and low chlorophyll content would contain relatively more slime growths. The carbon to chlorophyll ratios of the attached growths in the study reach of the Mississippi River are illustrated in Figure 8. The change to a community containing relatively more carbon as compared to chlorophyll is indicative of pollution by organic wastes, less productive of basic fish-food organisms and tends to produce less and consume more dissolved oxygen.

Inorganic pollutants also contributed to the severe reduction in the community of attached diatoms downstream from river mile 171.8 where the National Lead Company discharges its waste waters to the river. At stations 170.0 and 168.0, numbers of attached diatoms were the lowest for any station sampled. The artificial substrates were heavily coated with iron deposits.

The attached growths indicated recovery from the effects of pollution on biota of the Mississippi River downstream from mile 150; however, floating solids, mainly chunks of animal fat, remained conspicuous.

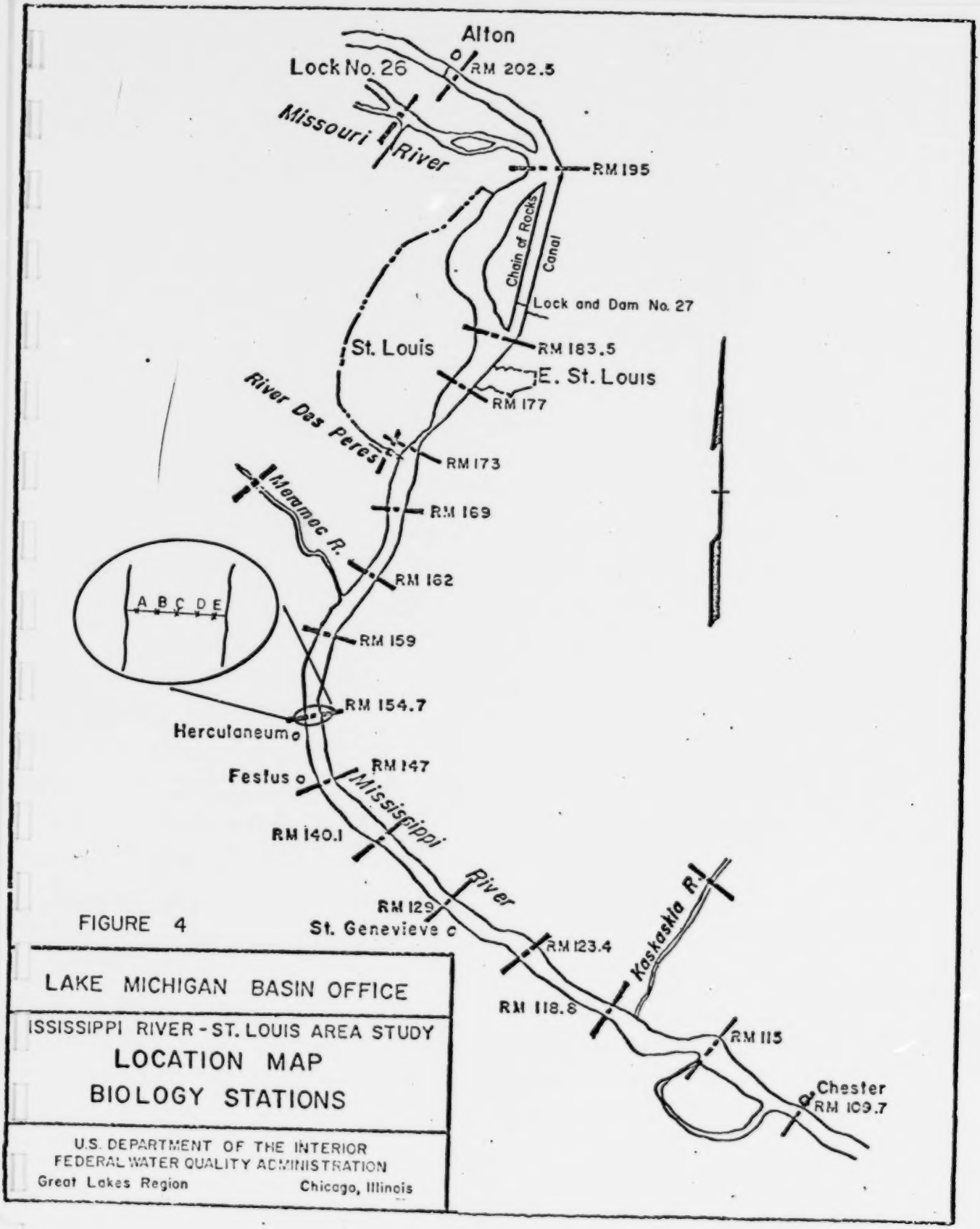


FIGURE 4

LAKE MICHIGAN BASIN OFFICE

ISSISSIPPI RIVER - ST. LOUIS AREA STUDY

LOCATION MAP

BIOLOGY STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
Great Lakes Region Chicago, Illinois

Table 5
Results of Benthic Biota Sampling

cation	Types of Bottom	Pollution Intolerant Organisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq. Meter
issouri 7.4				
A	sand, silt	none	sludgeworms 20	20
B	sand	none	none	0
C	sand	none	none	0
D	sand	scuds 10	none	10
E	sand	none	bloodworms 20	20
Mississippi 202.5				
A	sand	dragonfly nymph 10	sludgeworms 20 bloodworms 50 other diptera 60	140
B	sand	none	sludgeworms 180 bloodworms 230 other diptera 30	440
C	sand, gravel	caddisfly larvae 10	sludgeworms 80 bloodworms 90	180
D	sand	none	sludgeworms 90 bloodworms 30 other diptera 20	140
E	sand, oil	none	sludgeworms 860 bloodworms 50 leeches 10	920
Mississippi 195.0				
A	sand	caddisfly larvae 10	none	10
B	sand	none	none	0
C	sand	none	none	0
D	sand, rock	none	none	0
E	rock	none	sludgeworms 10 bloodworms 10	20

Table 5 (con't.)

;ation	Types of Bottom	Pollution Intolerant Organisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq. Meter
Mississippi 183.5				
A	sand	none	none	0
B	sand	none	none	0
C	sand	none	bloodworms 20	20
D	sand	none	sludgeworms 30	30
E	ooze, sand	none	sludgeworms 70 bloodworms 10 mayfly larvae 50	130
M ssissippi 177.0				
A	sand	none	none	0
B	samd	none	none	0
C	sand	none	none	0
D	silt	none	bloodworms 10	10
E	sand	caddisfly larvae 10	sludgeworms 200	210
lississippi 173.0				
A	sand	none	bloodworms 20	20
B	sand	none	none	0
C	sand	none	bloodworms 10 other diptera 90	100
D	sand	none	none	0
E	sand	none	none	0

Table 5 (con't.)

Station	Types of Bottom	Pollution Intolerant Organisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq.Meter
Mississippi 169.0				
A	sand, gravel	none	none	0
B	sand	none	none	0
C	sand, gravel	roundworms 10	none	10
D	sand	none	none	0
E	sand	none	none	0
Mississippi 162				
B	sand	none	none	0
C	sand, gravel	none	none	0
D	sand	none	none	0
E	sand, gravel	none	diptera 10	10
Mississippi 159				
A	gravel	none	none	0
B	sand, gravel	none	none	0
C	sand	none	none	0
D	sand, gravel	none	none	0
E	sand, gravel	none	none	0
Mississippi 154.7				
B	sand	none	none	0
C	sand	none	sludgeworms 10 bloodworms 20	30
D	sand	none	none	0
E	sand	none	bloodworms 20	20

Table 5 (con't.)

Station	Types of Bottom	Pollution Intolerant Organisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq. Meter
Mississippi 147				
A	sand, gravel	none	none	0
B	sand, gravel	scuds 10	none	10
C	sand, gravel	none	none	0
D	sand	none	none	0
Mississippi 140.1				
A	sand	none	none	0
B	sand, gravel	scuds 10	diptera 10	20
C	sand	none	none	0
D	sand, gravel	none	none	0
E	sand, oily	none	bloodworms <10	<10
Mississippi 129				
A	sand, gravel	none	mayfly larvae 10	10
B	sand, gravel	none	none	0
C	sand, gravel, rubble	none	none	0
D	sand	none	sludgeworms 20	20
Mississippi 123.4				
A	sand, gravel, rock	aquatic beetles 10	none	10
B	sand	scuds 10	none	10
C	sand, gravel	none	sludgeworms 10 bloodworms 10	20
D	sand, gravel	scuds 10	sludgeworms 20	30
E	sand	scuds 20	sludgeworms 20	40

Table 5 (cont'd)

Station	Types of Bottom	Pollution Intolerant Organisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq. Meter
Mississippi 118.8				
A	sand	none	none	0
B	sand	none	sludgeworms 20	20
C	sand	none	bloodworms 10	10
D	sand	none	none	0
E	sand	none	diptera 10	10
Mississippi 115				
A	clay, ooze	none	bloodworms 120 other diptera 20	140
B	sand	none	bloodworms 10 other diptera 80	90
C	sand	none	none	0
D	sand, detritus	none	none	0
E	sand	none	diptera 110	110
ississippi 109.7				
A	sand, gravel	none	bloodworms 10 other diptera 20	30
B	sand, gravel	none	none	0
C	sand	none	none	0
D	silt, sand	none	none	0

Table 5 (cont'd)

tation	Types of Bottom	Pollution Intolerant Orgnaisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq. Meter
ississippi 184.6 utfall below Lock and Dam 27 (Chain f Rocks Canal)				
Above outfall	rock	flatworms 140	sludgeworms 14170 fingernail clams 60	14370
Below outfall	ooze, sand	none	none	0
300' below outfall	ooze	none	sludgeworms 47520 bloodworms 10	47530
½ mile below outfall	sand, gravel	none	sludgeworms 26920	26920
River Des Peres 1.0	white caustic precipitate	none	none	0
Mississippi 171.5				
Above LeMay outfall	sand,silt	none	sludgeworms 6360 leeches 20	6380
Below Lemay outfall	sand	stonefly larvae 10	sludgeworms 6650 mayfly larvae 10	6670
eramec River 6.9				
A	ooze, gravel	none	sludgeworms 60 bloodworms 110 leeches 20 mayfly larvae 110	400
C	silt, gravel	none	sludgeworms 30 bloodworms 30 other diptera 30	90
E	ooze, gravel	unionid clams 10	sludgeworms 40 fingernail clams 30 bloodworms 30 mayfly larvae 20	120

Table 5 (cont'd)

Station	Types of Bottom	Pollution Intolerant Organisms (clean water) Per Sq. Meter	Pollution Tolerant or Facultative Organisms Per Sq. Meter	Total Organisms Per Sq. Meter
Waskaskia River 4.5				
A	Clay, ooze, detritus	none	sludgeworms 320 bloodworms 70 other diptera 120	510
C	clay, silt	none	sludgeworms 90 bloodworms 70 other diptera 60	220
E	clay, ooze	none	sludgeworms 460 bloodworms 80 other diptera 10 mayfly larvae 10	560

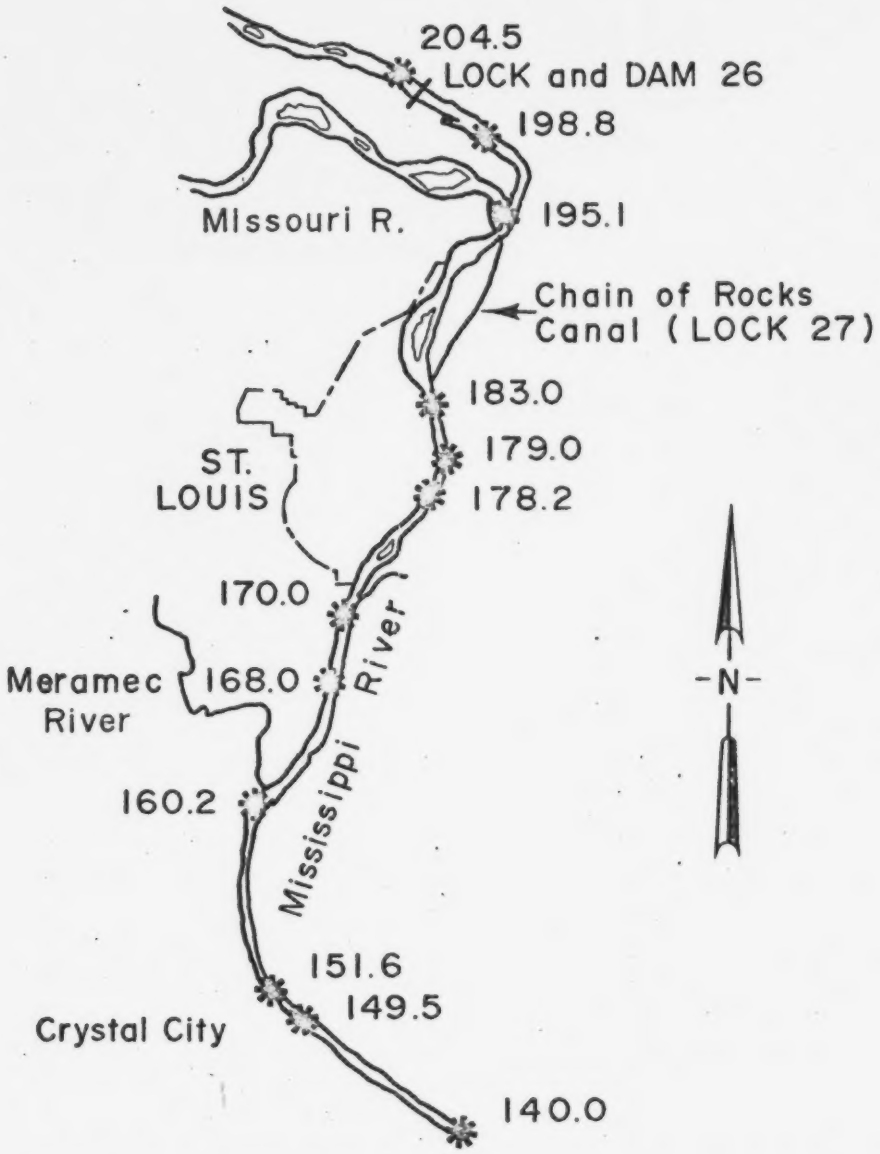


Figure 5

Stations sampled for periphyton in the Mississippi River from Lock and Dam 26 downstream to river mile 140.

Table 6 Summary of Analyses of Attached Growths

from the Mississippi River, St. Louis, Missouri

November - December, 1969

Station (River Mile)	Chlorophyll A µg/sq. inch	Carbon mg/sq. inch	Iron		Arsenic	Diatoms per sq. inch	Green Algae per sq. inch	Filamentous* Bacteria/sq. in.
			mg/ sq. inch	mg/gm Bottom Deposits@	mg/kg Bottom Deposits@			
204.5	3.3	3.4	0.2	-	-	194,000	9,000	1,600,000
198.8	2.1	4.1	0.3	-	-	136,000	10,000	33,900,000
195.1	2.3	7.6	0.5	-	-	166,000	10,000	26,200,000
183.0	0.5	2.6	0.4	-	-	9,000	3,000	8,300,000
179.0	0.6	3.3	0.2	-	-	36,000	2,000	9,800,000
178.2	0.5	4.9	0.3	-	-	31,000	2,000	20,000,000
172.5	-	-	-	3.2	1.5	-	-	-
172.0	-	-	-	4.1	2.3	-	-	-
171.7	-	-	-	5.0	8.7	-	-	-
171.5**	-	-	-	6.8**	5.7**	-	-	-
170.0	< 0.1	0.8	-	8.4	44.2	1,000	0	0
168.8	-	-	3.7	20.5	-	-	-	-
168.0	0.3	3.6	10.9	-	-	3.000	0	1,500,000
166.0	-	-	-	20.7	96.4	-	-	-
160.2	0.5	3.4	1.4	-	-	82,000	4,000	4,300,000
159.5	-	-	-	-	-	-	-	-
151.6	1.5	7.4	1.6	-	-	59,000	0	3,000,000
149.5	3.9	-	-	-	-	169.000	2,000	4,700,000
140.0	2.6	5.5	1.5	-	-	186,000	12,000	2,400,000

@Dry Weight.

*Tentatively identified. - No Sample

**See Note, page 55.

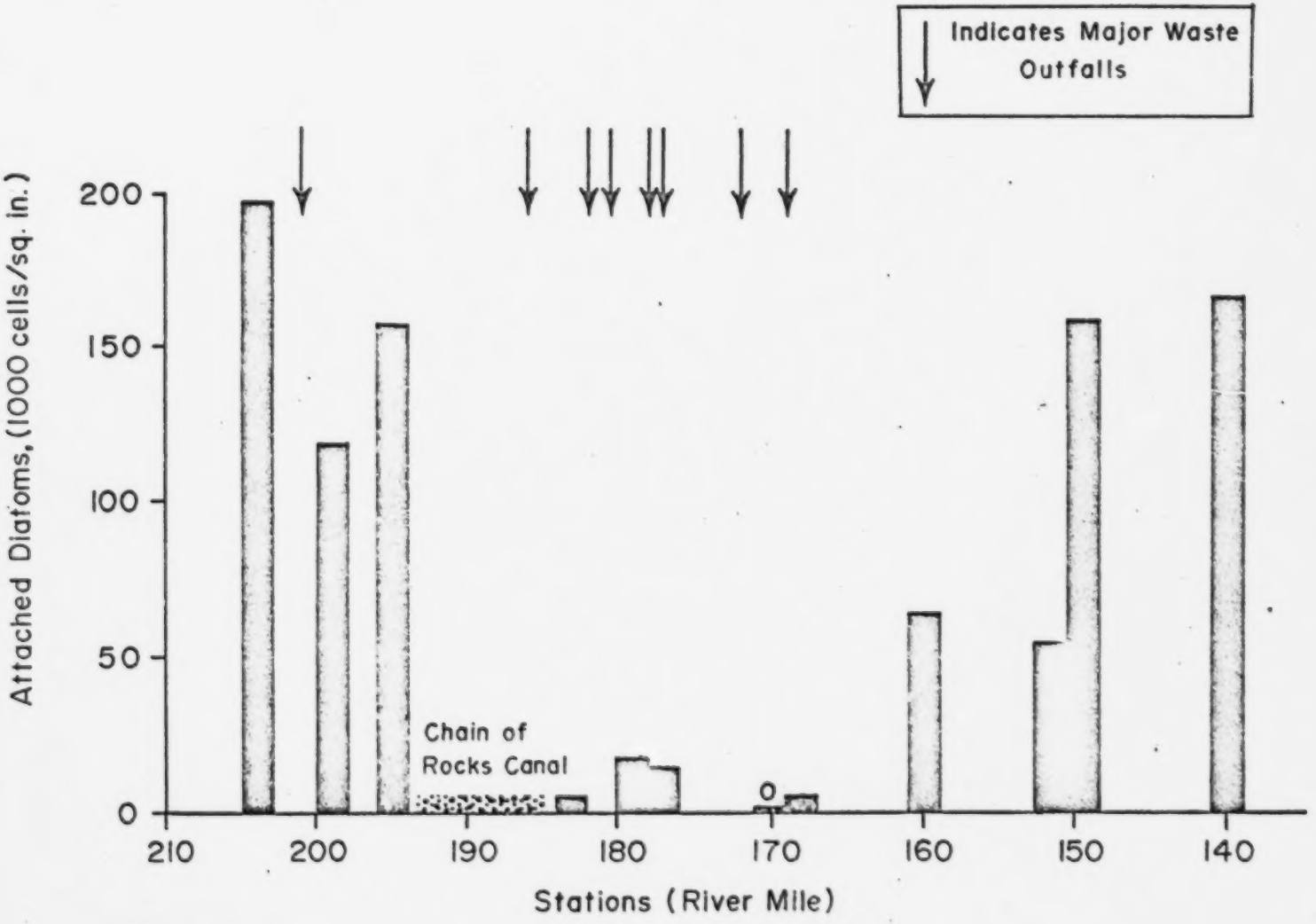


Figure 6

Effects of River Pollution on the Community of Attached Diatoms in the Mississippi River.

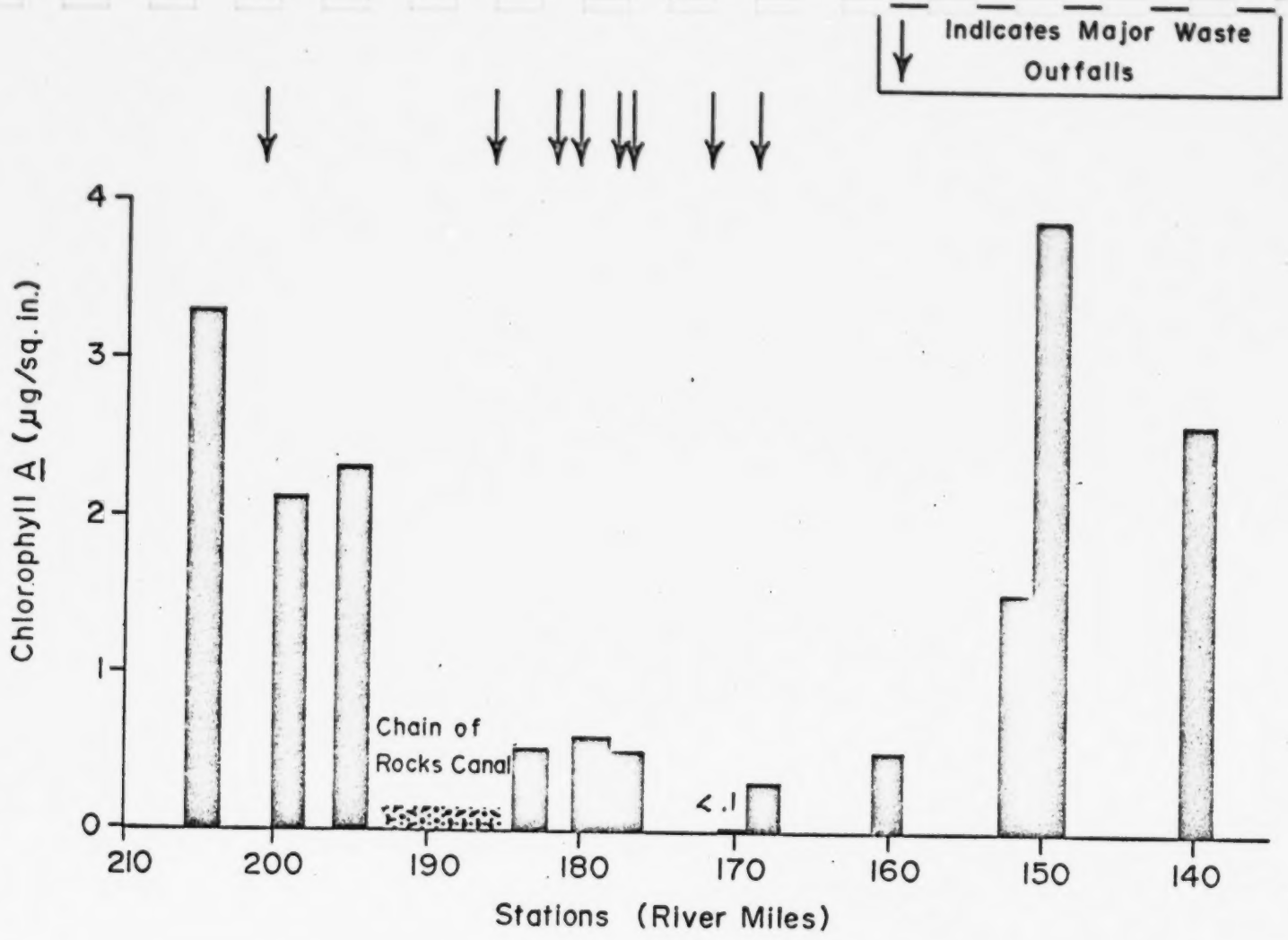


Figure 7

Effects of River Pollution on Bottom Attached Algae.

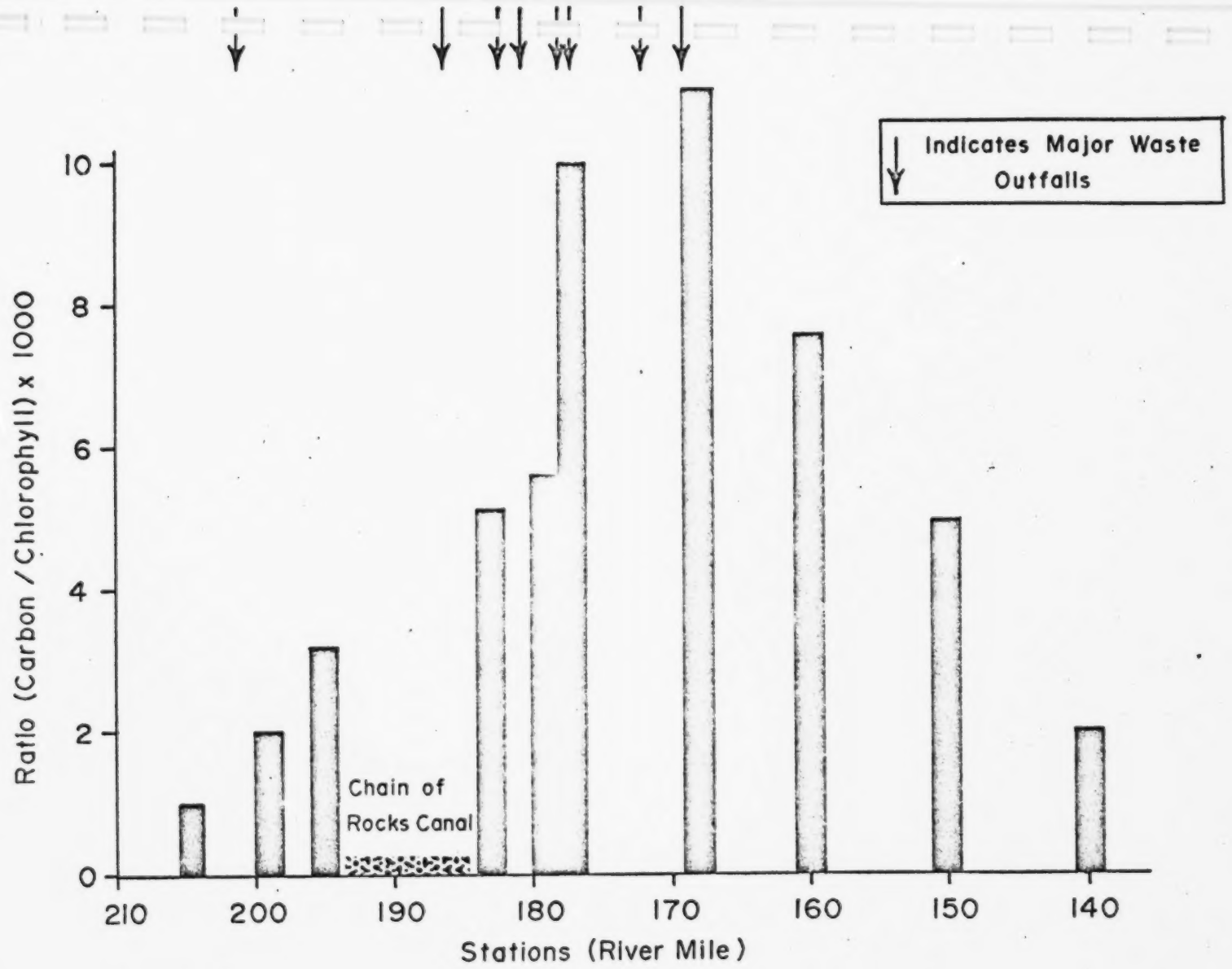


Figure 8

Relative Density of Attached Slimes, Mississippi River

Pesticides

Pesticides are chemicals used to control unwanted or obnoxious animals and plants. Their use has grown dramatically since the end of World War II. Over 875 million pounds were produced in the United States in 1965 which is a five fold increase over 1945. The most popular pesticides have been the chlorinated hydrocarbons including DDT, Aldrin, Endrin, Lindane, Dieldrin, Heptachlor, Chlordane, and Toxaphene, to name a few. These have been popular because of their ease of handling, persistence and their apparent lack of adverse effects on higher order animals. This lack of adverse effects has proven to be a delusion. The persistent or hard pesticides are very slow to break down and have accumulated in animals at the top of food chains. As a result, bird populations, particularly aquatic birds, have been decimated, fish have not been able to reproduce and some food fish have been declared inedible because of pesticides concentrated in their bodies. The situation has become so alarming that several states, including Illinois, have banned the use of DDT.

The Mississippi drains a large agricultural area where the use of pesticides is widespread, has a history of pesticide-caused fish kills, and has pesticide-producing industries on its banks. Pesticide samples were collected at four Mississippi River transects, the Missouri transect, the River Des Peres and the Kaskaskia River. See Figure 9, page 46. One sample was collected at each of the five points on each

transect and analyzed for Lindane, Aldrin, Heptachlor, Heptachlor Epoxide, Dieldrin, Endrin o,p,DDT, p,p'DDT DDE, DDD Methoxychlor, Chlordane and Toxaphene.

Paragraph 2d of the Missouri standards and SWB-13, rule 2.01, paragraph 5 of the proposed Illinois standards read "Substances toxic to humans, fish and wildlife or detrimental to agricultural, mining, industrial, recreational, navigational or other legitimate uses shall be limited to non-toxic or non-detrimental concentrations in the stream."

The National Committee on Water Quality Criteria states that any addition of persistent chlorinated hydrocarbon insecticides is likely to result in permanent damage to aquatic populations and recommends that their use should be avoided. The Committee further recommends that concentrations ranging from 1/10 to 1/100 of the 48 hour median tolerance limit valves be tentatively considered safe concentrations. The median tolerance limits (TLm), the concentration that kills 50 percent of the test organisms within a specified time span, has been reported for various pesticides. (Table III-5A, Report of the Committee on Water Quality Criteria.) Table 7 shows the most critical 48 hour TLm values for the pesticides considered in this study and compares them with the maximum concentration found in the streams.

Table 8 shows the distribution of each individual pesticide and of DDT and its derivatives. Each of the pesticides was found in

concentrations exceeding the tentative safe concentration at all stations where pesticides were measured. At station 202.5A in the Mississippi River the DDT concentration approached the 48-hour TLm for Daphnia pulex, an important link in aquatic food chains, and was 96 times the tentative safe concentration.

At station 169E in the Mississippi River, the concentration of Endrin was 36 times the tentative safe limit and the concentration of Dieldrin was more than 6 times the tentative safe limit.

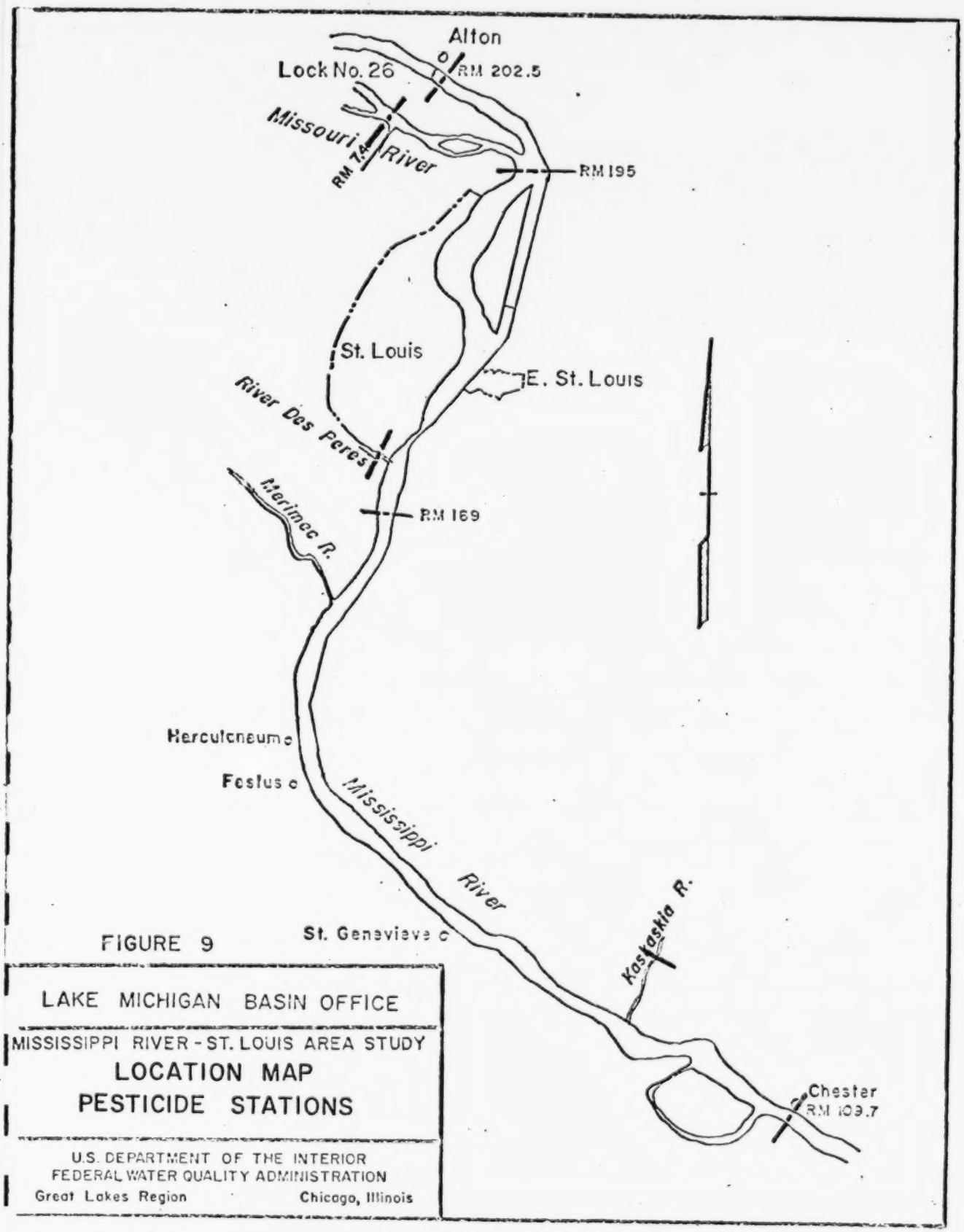


FIGURE 9

LAKE MICHIGAN BASIN OFFICE

MISSISSIPPI RIVER - ST. LOUIS AREA STUDY

LOCATION MAP
PESTICIDE STATIONS

U.S. DEPARTMENT OF THE INTERIOR
FEDERAL WATER QUALITY ADMINISTRATION
Great Lakes Region Chicago, Illinois

Table 7

Pesticides - Tentative Safe
Concentrations vs Concentrations Found

	Test Organism	48-Hour TLm ng/l	Tentative Safe Concentration* ng/l	Maximum Found ng/l
Lindane	Pteronarcys california (stonefly)	8,000	80	87
Aldrin	P. california (stonefly)	8,000	80	125
Endrin	Bluegill (fish)	200	2	72
Heptachlor	Peteronareela badia (stonefly)	4,000	40	56
DDT	Daphnia pulex (waterflea)	360	3.6	330
DDD	Gammarus lacustris (scuds)	1,800	18	61
Dieldrin	P. california (stonefly)	1,300	13	84

*Tentative Safe Concentration - 1/100 of 48-Hour TLm.

Table 8

Distribution of Pesticides

Lindane ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	87	24	NF	27	3
Missouri 7.4**	5	18	NF	2	21
Miss. 195	5	11	7	13	21
Miss. 169	9	8	1	6	24
Miss. 109.7	18	12	13	17	6
River Des Peres			6		
Kaskaskia River			26		

Aldrin ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	87	59	28	36	41
Missouri 7.4**	112	78	80	125	66
Miss. 195	38	112	9	65	56
Miss. 169	72	77	67	98	109
Miss. 109.7	71	52	54	73	30
River Des Peres			72		
Kaskaskia River			40		

Endrin ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	41	6	6	6	12
Missouri 7.4**	NF	NF	4	8	NF
Miss. 195	7	41	NF	NF	21
Miss. 169	28	16	17	56	72
Miss. 109.7	25	23	25	33	13
River Des Peres			24		
Kaskaskia River			24		

Table 8

Distribution of Pesticides (Cont'd)

Heptachlor ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	56	20	NF	19	8
Missouri 7.4**	4	10	3	3	19
Miss. 195	12	5	4	17	11
Miss. 169	24	6	10	36	37
River Des Peres			9		
Kaskaskia River			18		

Heptachlor Epoxide ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	D
Miss. 202.5	21	16	26	10	14
Missouri 7.4**	8	12	9	5	13
Miss. 195	4	7	11	5	6
Miss. 169	47	3	11	26	
Miss. 109.7	25	6	9	9	8
River Des Peres			7		
Kaskaskia River			7		

Total DDT (ng/l)
(o,p DDT, p,p' DDT, DDE and DDD)

	Missouri Side			Illinois Side	
Station	A	B	C	D	D
Miss. 202.5	330	161	225	96	127
Missouri 7.4**	121	127	78	212	90
Miss. 195	119	82	11	65	147
Miss. 169	136	119	148	254	421
Miss. 109.7	138	51	97	139	39
River Des Peres			121		
Kaskaskia River			227		

Table 8

Distribution of Pesticides (Cont'd)

o,p DDT ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	70	39	58	8	49
Missouri 7.4**	NF	7	7	4	22
Miss. 195	13	10	NF	46	55
Miss. 169	32	21	31	104	156
Miss. 109.7	25	23	21	44	13
River Des Peres			48		
Kaskaskia River			82		

p,p' DDT ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	103	85	92	9	36
Missouri 7.4**	98	75	45	199	32
Miss. 195	75	31	NF	NF	70
Miss. 169	51	78	81	96	122
Miss. 109.7	51	NF	48	65	10
River Des Peres			28		
Kaskaskia River			111		

DDD ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	43	21	16	22	26
Missouri 7.4**	15	NF	NF	5	20
Miss. 195	22	17	NF	10	10
Miss. 169	33	14	21	15	61
Miss. 109.7	44	18	19	21	10
River Des Peres			25		
Kaskaskia River			14		

Table 8

Distribution of Pesticides (Con'd)

DDE ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	112	16	58	57	16
Missouri 7.4**	8	44	13	4	17
Miss. 195	9	24	11	9	11
Miss. 169	20	5	15	40	82
Miss. 109.7	18	10	10	9	7
River Des Peres			21		
Kaskaskia River			20		

Dieldrin ng/l

	Missouri Side			Illinois Side	
Station	A	B	C	D	E
Miss. 202.5	22	11	73	14	16
Missouri 7.4**	NF	16	20	NF	12
Miss. 195	18	42	9	42	28
Miss. 169	19	10	37	75	84
Miss. 109.7	16	13	15	21	18
River Des Peres			6		
Kaskaskia River			42		

NF - Not detected at sensitivity of test

** Transect located entirely in state of Missouri. Point A is across the South bank and point E is near the North bank.

Sediment Chemistry

The chemical content of the bottom sediments is an indicator of the prevalent and historical quality of the superimposed water mass. Sediments accumulate over a period of time and integrate the varying water quality conditions that occur during that time.

The use of sediment chemistry as an indicator of stream quality is relatively new and may be imprecise in a river where the bottom is shifted by currents. Few data have been published on the concentration of pollution indicating substances to be found in sediments. Experience with more than fifty different harbors in the Great Lakes has been accumulated during recent studies to determine the degree of pollution of the sediments within these harbors. Sediment criteria, developed on the basis of this experience, have been applied to the appraisal of the Mississippi River bottom sediments.

As shown in Table 9, iron and phosphorus dry weight concentrations exceeded 15,000 and 500 mg/kg respectively in all samples. These values are indicative of polluted sediments. Phenol concentrations exceeded 1.0 mg/kg and were considered high for a number of locations including the Missouri River, the River Des Peres, the Kaskaskia River and the Mississippi River at miles 184.6 and 183.5. At Mississippi river mile 184.6 the sample was collected at the mouth of the outfall to the Chain of Rocks Canal, previously discussed on page 26. A sample was also collected 300 feet downstream from the outfall. Both samples indicated a heavily polluted sediment. At the

latter station the volatile solids were 12.3 percent, phosphorus exceeded 5,000 mg/kg and organic nitrogen exceeded 3,500 mg/kg. Other constituents were equally high as recorded in Table 9. The sediment samples at Stations 184.1E and 183.5E were affected by the outfall to the Chain of Rocks Canal. These samples had phosphorus concentrations that reached 729 mg/kg and ammonia nitrogen of 90 mg/kg. At mile point 171.5A, upstream from the LeMay Sewage Treatment Plant outfall, the sediments were moderately polluted but had a high concentration of arsenic (7.79 mg/kg) and chromium (64 mg/kg) that may be due to the proximity of the National Lead Company discharges. Iron at 31,000 mg/kg was also high at this station. At Mississippi River mile 140.1E the sediment constituents were generally lowest in value of any of the stations studied in this investigation. The concentrations of phosphorus and iron, 533 and 15,147 mg/kg respectively, were higher than the concentrations of these constituents found in polluted harbors of the Great Lakes. It is possible that natural iron compounds are present in the area, which elevate all of the iron concentrations.

The sediments in the Missouri River (mile 7.4) contain concentrations of phosphorus and ammonia (765 and 81 mg/kg respectively) that were high and may reflect the heavy use of fertilizers in the Basin. The phenol concentration was 1.13 mg/kg, which is high in view of the fact that no phenol was found in the water samples during the present study.

The sediments in the River Des Peres were heavily polluted with very high concentrations of COD, phosphorus, ammonia, organic nitrogen, phenol, sulfide, zinc, lead, and chromium.

The Meramec River sediments were moderately polluted but contained high concentrations of metals such as iron, barium, titanium, manganese, lead and zinc. The sources of these metals have not been determined.

The sediments in the Kaskaskia River were light to moderately polluted. The concentrations of phosphorus and iron were higher than in sediments from Great Lakes harbors but lower than most in this study.

Table 9

Results of Sediment Chemistry Sampling

Station	Tot. Solids %	Vol. Solids %	C.O.D. mg/kg	Phosphorus mg/kg	NH_3-N mg/kg	Organic N mg/kg
Miss. 140.1 E	71.3	2.5	15,410	533	5.2	371
Miss. 183.5 E	61.2	3.3	39,090	634	56	773
Miss. 184.1 E	67.5	3.2	31,945	729	90	837
Missouri 7.4 E	64.3	3.9	34,770	765	81	708
River Des Peres 1.0 C	51.8	7.5	107,430	6,660	421	1,719
Meramec River 6.9 C	45.2	4.6	37,310	438	16	1,204
Kaskaskia River 4.5 C	62.4	3.3	34,545	649	24	741
Miss. 171.5 (above LeMay outfall)	62.9	4.3	33,060	824	213	832
Miss. 184.6 (Chain of Rocks Canal)	46.2	16.8	305,000	5,600	662	4,688
300' below outfall	44.2	12.3	176,000	5,570	584	3,686

	Phenol mg/kg	Arsenic mg/kg	Sulfide mg/kg	Iron mg/kg	Barium mg/kg	Titanium mg/kg	Manganese mg/kg
Miss. 140.1 E	0.279	2.67	9.8	15,147	289	4.2	251
Miss. 183.5 E	1.53	3.51	40	17,812	216	4.9	534
Miss. 184.1 E	0.218	2.30	17	17,333	144	1.5	415
Missouri 7.4 E	1.13	2.96	5.4	17,885	359	3.1	417
River Des Peres 1.0 C	2.27	5.69	105	24,131	386	5.8	790
Meramec River 6.9	0.48	5.31	33	32,965	575	8.9	1,451
Kaskaskia River 4.5 C	2.56	2.80	17	22,596	192	4.8	614
Miss. 171.5 (above LeMay outfall)	0.345	7.79 *	40	31,637*	251	6.4	242
Miss. 184.6 (Chain of Rocks Canal) at outfall	3.95	3.90	61	33,333	329	2.2	303
300' below outfall	2.43	12.0	415	53,620	244	2.3	500

*Difference in values compared to similar sample location shown on page 36, Table 9, is due to samples being taken at a different time and imprecise sample location.

Table 9 (cont'd)

Station	Copper mg/kg	Cadmium mg/kg	Nickel mg/kg	Zinc mg/kg	Lead mg/kg	Chromium mg/kg
Miss. 140.1 E	11	1.4	34	69	45	21
Miss. 183.5 E	23	1.6	29	44	74	36
Miss. 184.1 E	21	NF	33	37	42	39
Missouri 7.4 E	17	NF	33	30	53	9.3
River Des Peres 1.0 C	37	5.8	68	212	407	43
Meramec River 6.9 C	24	NF	64	159	188	35
Kaskaskia River 4.5 C	18	NF	35	27	59	6.4
Miss. 171.5 (above LeMay outfall)	37	1.6	38	105	87	64
Miss. 184.6 (Chain of Rocks Canal) at outfall	63	4.3	121	216	435	158
300' below outfall	102	2.3	127	249	441	206

NF - None found within sensitivity of test.

All results are reported on a dry weight basis.

National Lead Company

Special investigations were made of National Lead Company outfalls and of bottom sediments immediately above and below the outfalls because information furnished by the Company indicate that the provisions of the 1958 enforcement conference "Pollution of Interstate Waters, Mississippi River, St. Louis Metropolitan Area" have not been complied with.

National Lead Company, St. Louis, Missouri, in March 1968, applied to the Corps of Engineers for a permit to construct an underwater sewer outfall approximately 270 ft. into the Mississippi River. This outfall would discharge approximately 22,000,000 gallons per day of highly acidic untreated wastes containing approximately 1,330 tons of solids (210 tons of which are settleable solids) at an average pH of 1.8. The waste results from the manufacture of titanium dioxide for paint pigments and is now discharged from several individual outfalls at the river's edge.

FWQA, after a review of waste discharge data, objected to the issuance of the permit on the following basis:

1) Wastes from National Lead Company's St. Louis, Missouri Plant are now discharged untreated to the Mississippi River;

2) The proposed project to discharge these wastes at a different location in the river where greater dilution and dispersion takes place does not change the quality or strength of the wastes in any way;

3) The FWQA does not condone the continuing discharge of untreated wastes to the Mississippi River;

4) The continuing discharge of these wastes is causing water quality degradation due to color, turbidity and suspended solids.

In addition to the above formal objections voiced in correspondence, FWQA considers these discharges to be incompatible with Mississippi River water quality standards and the St. Louis Area Enforcement Conference recommendations. The present discharge is unsightly, heavily laden with solids, highly acidic, and exhibits a definite color. The result is the discoloration of the downstream river banks, the accumulation of bottom deposits, numerous unknown chemical reactions, and an aesthetic nuisance.

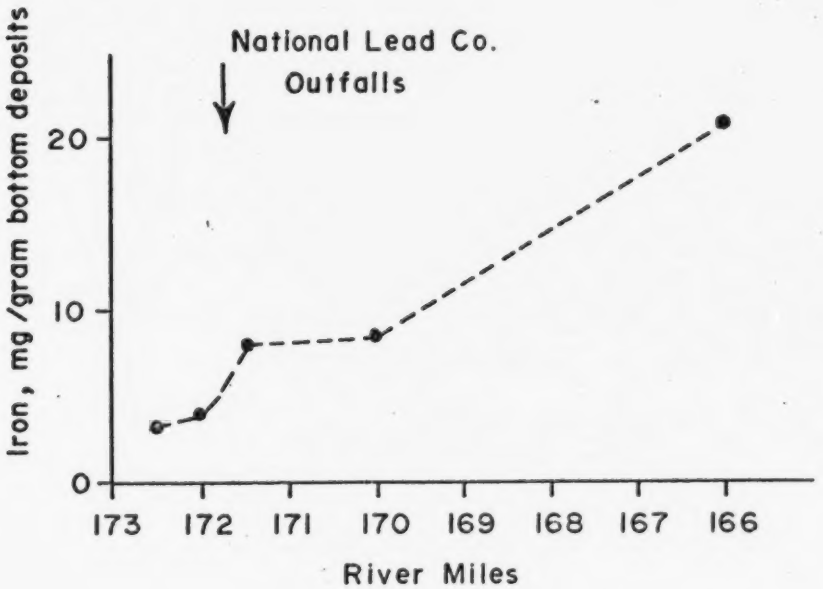
On December 12, 1969, nine samples were collected by boat from the outfalls of the National Lead Company. Samples were taken at each major discharge to the river in order, working from south to north. Sample No. 1 was taken at the mouth of the southernmost outfall pipe. The remaining samples were taken from small streams formed by the discharge of several outfalls each and are a composite of the wastes from these outfalls. The shallow water and soft sludge banks made it impossible to reach the individual outfalls. Thus, the results of the analyses of these samples, presented in Table 10, are given in qualitative terms only.

Table 10 shows that outfall streams 3, 4, 5 and 9 were extremely acid and had very high concentrations of dissolved solids, COD, phosphorus, sulfate, chloride, magnesium, sodium, iron, manganese,

nickel, zinc and chromium. Outfall No. 1 contained a high concentration of titanium. Outfalls 1, 3, 5, 7 and 9 contained high concentration of arsenic. Outfalls 5 and 9 had particularly high arsenic concentrations containing 16,300 ug/l and 6,800 ug/l, respectively.

Increased arsenic concentrations were observed in the bottom sediments downstream from National Lead's waste discharges. Upstream from National Lead Company, arsenic concentrations ranged from 1.5 to 2.3 mg/kg of sediment; in a six-mile reach downstream, concentrations ranged from 5.7 to 96.4 mg/kg of sediment (Table 6).

Outfalls 3, 4 and 9 contained very high concentrations of iron (Table 10). Iron accumulations on glass substrates and in river sediments are illustrated in Figure 10. Although these results are only qualitative, the high concentrations correlate with an estimated discharge of more than 200 tons of iron per day by the National Lead Company.



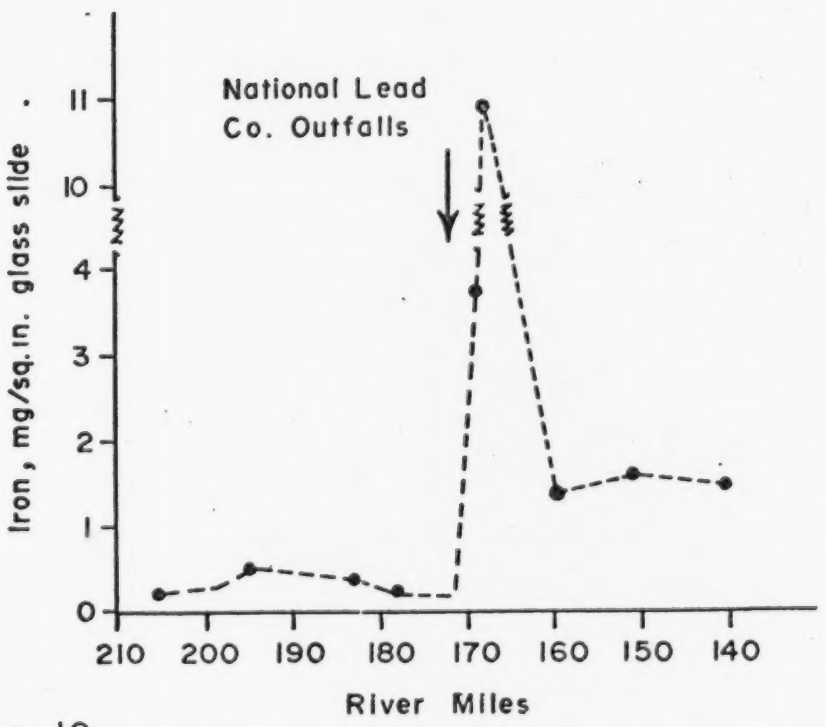


Figure 10

Iron Accumulation on Glass Slides and in Bottom Deposits.

Table 10

Results of National Lead Outfall Sampling

Sample	Dis. Solids mg/l	Susp. Solids mg/l	Turbidity JCU	True Color Units	Spec. Cond. umho/CM	pH
1	585	145	25	5	725	6.45
2	480	90	5.6	10	670	6.65
3	9,010 *	260	2.2	20	16,000	2.00
4	40,330 *	290	65	50	56,000	1.65
5	21,905 *	6,635	2.4	25	51,000	1.55
6	445	3,160	.99	20	720	7.25
7	440	160	.85	20	700	6.15
8	425	125	.46	60	620	6.50
9	5,255 *	3,855	100	5	17,000	1.75

* Sulfuric acid in effluent may cause result to be high.

Sample	Acidity mg/l	C.O.D. mg/l	Tot. Phos. mg/l. asP	NH_3-N mg/l	NO_2+NO_3-N mg/l	Org. N mg/l
1	47	33	0.704	0.45	1.3	1.0
2	69	30	0.464	0.68	1.7	1.0
3	4,000	252	2.13	0.87	0.07	1.3
4	19,125	1,226	3.20	0.75	0.14	2.5
5	12,200	1,311	26.0	1.3	0.15	4.1
6	140	114	5.33	0.95	0.11	2.4
7	99	40	0.575	0.57	0.08	1.1
8	159	31	0.557	0.68	0.12	1.0
9	1,575	176	7.46	1.1	0.08	1.1

Table 10

Results of National Lead Outfall Sampling (Cont'd)

Sample	Fluoride mg/l	Arsenic ug/l	Sulfate mg/l	Chloride mg/l	Silica mg/l	MBAS mg/l	Calcium mg/l
1	0.70	151	310	22	50	0.16	32
2	0.72	99	235	23	45	0.15	47
3	0.92	144	6,600	24	135	0.10	70
4	2.1	66	30,000	40	75	0.08	331
5	2.4	16,300	20,000	132	2,327	0.09	74
6	0.82	89	188	28	289	0.20	327
7	0.67	171	184	24	99	0.13	48
8	0.67	83	150	22	70	0.13	49
9	1.2	6,800	4,900	55	1,553	0.08	62

Sample	Magnesium mg/l	Sodium mg/l	Potassium mg/l	Total Iron mg/l	Manganese mg/l	Copper mg/l	Cadmium mg/l
1	20	61	6.0	24.9	0.328	0.035	0.003
2	26	50	5.4	4.88	0.166	0.021	0.002
3	48	66	16	2138	15.1	0.031	0.005
4	320	116	46	7420	83.6	0.028	0.018
5	90	116	22	1.78	27.4	3.41	0.011
6	36	51	5.5	39.0	1.2	0.065	0.005
7	24	49	5.3	2.32	0.166	NF	NF
8	28	48	5.3	4.92	0.154	0.016	NF
9	52	87	9.2	8190	12.9	1.67	0.002

NF - None found within sensitivity of test.

Sample	Nickel mg/l	Zinc mg/l	Lead mg/l	Chromium mg/l	Barium mg/l	Titanium mg/l
1	0.059	0.122	0.062	0.122	1.44	9.60
2	0.031	0.070	0.102	0.070	1.43	3.00
3	0.352	3.82	0.164	0.165	0.362	0.033
4	0.648	20.3	0.364	0.310	0.874	0.061
5	0.604	2.58	0.412	0.424	NF	0.177
6	0.062	0.216	6.52	0.336	1.19	0.005
7	0.043	0.048	0.034	0.058	0.380	0.004
8	0.034	0.052	0.078	0.087	1.19	0.004
9	0.426	0.928	0.328	0.396	0.480	0.059

APPENDIX

Appendix Microbiology Results

MISSISSIPPI RIVER STUDY
ST. LOUIS REACH
December 1-12, 1959

DATE	IMBO NO.*	COUNTS/100 ML TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Missouri River M.P.7.4A				
Dec. 1	No Sample	–	–	–
2	5461	68,000	2,000	4,400
3	5377	65,000	790	3,900
4	5564	47,000	1,200	3,300
5	5602	28,000	920	2,000
6	5684	64,000	1,200	2,300
7	5737	52,000	2,300	2,500
8	5804	48,000	1,800	1,900
9	5863	41,000	2,200	8,200
10	5947	80,000	3,000	6,000
11	5961	42,000	1,600	3,600
12	6069	48,000	1,400	2,400
Average		53,000	1,700	3,700
Missouri River M.P. C				
Dec. 1	No Sample	–	–	–
2	5462	56,000	2,200	5,000
3	5379	53,000	1,100	4,400
4	5565	59,000	970	2,400
5	5604	24,000	1,900	1,800
6	5685	Laboratory Accident	4,200	2,700
7	5739	72,000	2,500	3,700
8	5805	57,000	2,500	3,600
9	5865	8,200	1,700	4,900
10	5948	53,000	2,700	5,800
11	5963	39,000	2,300	4,300
12	**	55,000	1,200	2,300
Average		48,000	2,100	3,700
Missouri River M.P. E				
Dec. 1	No Sample	–	–	–
2	5463	61,000	2,400	4,300
3	5381	60,000	910	4,100
4	5566	47,000	1,100	3,000
5	5605	21,000	950	1,600
6	5686	62,000	1,900	2,500
7	5741	60,000	2,300	4,800
8	5806	55,000	3,000	4,400
9	5867	73,000	2,000	4,300
10	5949	47,000	2,800	5,500
11	5963	35,000	1,500	3,800
12	6080	36,000	1,300	2,800
Average		51,000	1,700	3,700

DATE	IMBO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 202.5 A				
Dec. 1	No Sample	–	–	–
2	5464	800	20	< 10
3	5382	970	46	30
4	5567	700	40	14
5	5607	680	56	6
6	5687	810	210	22
7	5727	460	40	32
8	5807	1,800	46	72
9	5858	380	400	36
10	5950	340	30	40
11	5996	390	56	12
12	6031	400	92	38
Average		700	94	28
Mississippi River M.P. 202.5 C				
Dec. 1	No Sample	–	–	–
2	5465	1,200	50	20
3	5384	2,300	Laboratory Accident	110
4	5568	1,900	50	26
5	5609	610	160	16
6	5688	1,000	40	24
7	5729	730	40	26
8	5808	420	70	12
9	5878	720	40	46
10	5951	440	30	90
11	5998	360	24	18
12	6032	390	60	46
Average		920	56	39
Mississippi River M.P. 202.5 E				
Dec. 1	No Sample	–	–	–
2	5466	2,100	90	30
3	5386	2,800	240	150
4	5569	3,300	150	110
5	5611	1,600	24	100
6	5689	640	340	180
7	5731	810	40	140
8	5809	610	180	48
9	5872	770	660	110
10	5952	1,400	160	180
11	6030	700	64	38
12	6033	570	90	44
Average		1,400	190	100

DATE	LMSO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 495.0 A				
Dec. 1	No Sample	—	—	—
2	5467	2,400	80	Laboratory Accident
3	5387	170,000	990	3,000
4	5570	29,000	1,200	1,600
5	5612	32,000	1,100	4,100
6	5690	58,000	1,500	2,800
7	5732	65,000	3,700	4,700
8	5810	41,000	3,600	4,400
9	5873	67,000	4,400	4,700
10	5953	57,000	2,300	3,800
11	5969	32,000	2,100	1,600
12	6034	45,000	1,500	3,200
Average		54,000	2,000	3,400
Mississippi River M.P. 495.0 C				
Dec. 1	No Sample	—	—	—
2	5468	47,000	2,300	4,800
3	5389	49,000	820	3,700
4	5571	39,000	850	4,100
5	5614	43,000	910	2,600
6	5691	59,000	1,700	3,100
7	5734	51,000	1,900	4,200
8	5811	45,000	2,100	5,200
9	5875	74,000	2,400	3,300
10	5954	54,000	2,400	4,800
11	5993	47,000	1,200	2,500
12	6035	36,000	1,200	3,500
Average		49,000	1,600	3,800
Mississippi River M.P. 495.0 E				
Dec. 1	No Sample	—	—	—
2	5469	43,000	2,200	3,400
3	5391	9,600	1,200	220
4	5572	3,500	460	230
5	5616	41,000	2,400	560
6	5692	8,500	1,400	8,100
7	5735	6,200	980	2,300
8	5812	5,600	1,000	1,700
9	5877	38,000	2,900	800
10	5955	3,800	600	2,300
11	5995	21,000	1,500	320
12	6036	3,000	340	870
Average		17,000	1,400	1,900

DATE	IMBO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 183.5 A				
Dec. 1	No Sample	–	–	–
2	5470	110,000	9,700	9,800
3	5392	100,000	5,700	12,000
4	5573	39,000	2,200	2,300
5	5617	28,000	2,400	6,500
6	5693	74,000	1,600	3,100
7	5737	93,000	2,600	3,100
8	5813	64,000	3,200	5,300
9	5878	83,000	3,600	7,800
10	5956	69,000	4,200	6,300
11	6001	27,000	3,800	2,400
12	6037	38,000	550	4,500
Average		66,000	3,600	5,700
Mississippi River M.P. 183.5 C				
Dec. 1	No Sample	–	–	–
2	5471	26,000	1,000	190
3	5394	12,000	610	160
4	5574	14,000	720	1,300
5	5619	13,000	780	12,000
6	5694	33,000	770	610
7	5739	20,000	1,100	1,600
8	5814	31,000	3,000	2,100
9	5880	97,000	14,000	11,000
10	5957	20,000	1,500	2,600
11	6003	34,000	1,600	2,100
12	6038	11,000	600	1,600
Average		28,000	2,300	3,200
Mississippi River M.P. 183.5 E				
Dec. 1	No Sample	–	–	–
2	5472	36,000	2,600	750
3	5395	64,000	2,700	6,000
4	5575	25,000	3,100	22,000
5	5621	66,000	6,200	49,000
6	5695	27,000	2,900	25,000
7	5741	45,000	3,700	11,000
8	5815	34,000	3,900	800
9	5882	100,000	6,400	11,000
10	5958	62,000	4,200	26,000
11	6005	39,000	3,200	7,900
12	6039	43,000	3,200	36,000
Average		49,000	3,800	17,000

DATE	LMSO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 477.0 A				
Dec. 1	No Sample	—	—	—
2	5473	52,000	3,500	15,000
3	5397	73,000	3,300	35,000
4	5576	66,000	3,400	3,200
5	5622	70,000	8,200	47,000
6	5696	58,000	2,000	3,500
7	5742	65,000	3,000	4,600
8	5816	100,000	22,000	17,000
9	5883	78,000	2,600	6,700
10	No Sample	—	—	—
11	6006	110,000	21,000	32,000
12	6090	62,000	8,800	4,200
Average		73,400	7,780	1,630
Mississippi River M.P. 477.0 C				
Dec. 1	No Sample	—	—	—
2	5474	43,000	2,500	3,100
3	5399	55,000	1,200	2,500
4	5577	27,000	1,200	3,100
5	5624	31,000	1,000	6,600
6	5697	44,000	970	910
7	5744	40,000	1,500	4,400
8	5817	47,000	1,900	3,200
9	5885	71,000	1,600	3,800
10	No Sample	—	—	—
11	6008	24,000	1,800	3,900
12	6091	24,000	900	2,200
Average		40,600	1,460	3,370
Mississippi River M.P. 477.0 E				
Dec. 1	No Sample	—	—	—
2	5475	45,000	3,000	330
3	5401	54,000	2,900	1,000
4	5578	35,000	1,100	6,900
5	5626	24,000	3,600	11,000
6	5693	26,000	900	4,300
7	5746	58,000	3,200	2,300
8	5818	31,000	700	4,200
9	5887	35,000	1,800	2,300
10	No Sample	—	—	—
11	6008	33,000	5,300	3,700
12	6092	46,000	2,900	12,000
Average		38,700	2,540	4,800

DATE	IMBO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 173.0 A				
Dec. 1	5402	71,000	2,500	6,800
2	5476	74,000	5,400	30,000
3	5499	81,000	3,600	17,000
4	5579	36,000	940	3,600
5	5627	28,000	2,200	11,000
6	5699	110,000	7,400	15,000
7	5747	69,000	4,500	9,700
8	5819	66,000	6,800	15,000
9	5888	63,000	2,700	13,000
10	No Sample	–	–	–
11	6011	67,000	11,000	14,000
12	6093	32,000	4,500	14,000
Average		63,000	4,700	14,000
Mississippi River M.P. 173.0 C				
Dec. 1	5404	44,000	1,800	1,000
2	5477	29,000	2,300	2,500
3	5501	35,000	1,900	2,100
4	5508	28,000	890	2,700
5	5629	26,000	1,300	4,100
6	5700	49,000	1,100	2,100
7	5749	45,000	1,900	2,200
8	5820	54,000	3,400	3,300
9	5890	57,000	2,500	5,200
10	No Sample	–	–	–
11	6013	27,000	2,200	1,900
12	6094	28,000	1,200	3,400
Average		38,000	1,900	2,800
Mississippi River M.P. 173.0 E				
Dec. 1	5405	68,000	3,900	4,100
2	5478	49,000	3,400	750
3	5503	44,000	3,300	1,700
4	5581	29,000	1,100	8,100
5	5631	23,000	2,800	5,600
6	5701	41,000	2,800	3,300
7	5751	43,000	3,200	2,700
8	5821	28,000	2,300	1,500
9	5892	47,000	2,300	3,200
10	No Sample	–	–	–
11	6015	45,000	5,900	3,300
12	6095	30,000	2,500	2,400
Average		41,000	3,100	3,300

DATE	LMBO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
River Des Peres 1.0C				
Dec. 1	**	< 100	< 10	240
2	5496	10	< 10	1,600
3	**	< 100	< 100	< 100
4	5599	< 100	< 100	30
5	5581	< 10	< 10	< 10
6	5719	< 10	< 10	2,800
7	**	Est. 60,000	30,000	31,000
8	5839	2,100	< 100	< 100
9	5942	< 10	< 10	10
10	5982	< 10	< 10	< 10
11	6064	< 10	< 10	240
12	6113	42,000	1,100	26,000
Average		8,700	2,600	5,200
Mississippi River M.P. 162.0 A				
Dec. 1	5413	61,000	4,200	5,600
2	5479	50,000	4,500	17,000
3	5509	95,000	5,800	21,000
4	5582	47,000	3,000	31,000
5	5636	41,000	3,900	20,000
6	5702	42,000	4,500	11,000
7	5756	220,000	18,000	35,000
8	5822	55,000	5,500	2,900
9	5897	48,000	5,000	11,000
10	5965	51,000	4,000	22,000
11	6020	31,000	3,500	34,000
12	6096	33,000	3,700	2,600
Average		64,000	5,600	18,000
Mississippi River M.P. 162.0 C				
Dec. 1	5415	28,000	1,600	440
2	5480	36,000	2,700	1,500
3	5511	50,000	1,400	2,400
4	5583	28,000	1,400	3,500
5	5633	36,000	3,000	9,800
6	5703	150,000	6,300	12,000
7	5758	130,000	5,900	14,000
8	5823	25,000	920	1,100
9	5899	64,000	2,900	4,500
10	5966	44,000	3,200	3,400
11	6022	22,000	1,100	3,600
12	6097	28,000	3,300	8,700
Average		53,000	2,800	5,400

DATE	LMBO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 62.0 E				
Dec. 1	5417	48,000	3,100	320
2	5481	43,000	3,400	900
3	5513	200,000	4,800	1,800
4	5584	65,000	2,000	5,300
5	5640	42,000	2,600	5,300
6	5704	59,000	2,500	2,200
7	5760	44,000	2,000	2,500
8	5824	29,000	1,600	360
9	5901	61,000	5,900	6,000
10	5967	36,000	1,600	2,100
11	6023	43,000	2,900	2,700
12	6093	53,000	3,400	2,400
Average		60,000	3,000	2,700
Meramec River 6.9 C				
Dec. 1	No Sample	—	—	—
2	5497	1,800	70	60
3	**	700	16	80
4	5600	600	40	84
5	5582	150	16	56
6	5720	29,000	16	70
7	**	480	20	150
8	5840	2,100	140	410
9	5943	4,500	220	290
10	5983	1,300	100	170
11	6065	180	72	220
12	6114	360	48	190
Average		3,770	69	160
Mississippi River M.P. 254.7 A				
Dec. 1	5423	110,000	2,800	1,200
2	5482	62,000	5,600	9,300
3	**	100,000	3,900	8,600
4	5585	35,000	2,200	3,500
5	5645	35,000	2,300	16,000
6	**	81,000	4,800	17,000
7	5765	110,000	5,700	17,000
8	5825	71,000	6,200	8,200
9	5906	64,000	4,000	5,200
10	No Sample	—	—	—
11	6028	36,000	4,300	24,000
12	**	44,000	3,800	26,000
Average		68,000	4,200	12,000

DATE	IMSO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 754.7 C				
Dec. 1	5425	44,000	2,200	330
2	5483	42,000	3,000	1,100
3	**	54,000	2,800	1,500
4	5586	29,000	3,200	2,200
5	5647	15,000	1,200	3,600
6	5706	42,000	2,700	5,000
7	5767	63,000	2,300	5,000
8	5826	31,000	2,900	1,000
9	5908	54,000	1,300	1,100
10	No Sample	—	—	—
11	6030	52,000	7,100	16,000
12	6100	33,000	1,600	3,100
Average		42,000	2,800	3,600
Mississippi River M.P. 754.7 E				
Dec. 1	5427	55,000	2,000	220
2	5484	37,000	2,300	730
3	**	46,000	2,200	1,300
4	5587	31,000	3,100	3,600
5	5649	33,000	2,200	3,500
6	5707	55,000	2,500	7,700
7	5769	54,000	3,900	7,100
8	5827	31,000	2,500	3,000
9	5910	54,000	3,900	2,300
10	No Sample	—	—	--
11	6032	38,000	4,100	12,000
12	6101	37,000	2,700	2,300
Average		43,000	3,000	4,000
Mississippi River M.P. 740.1 A				
Dec. 1	5432	84,000	4,600	400
2	5485	55,000	6,600	25,000
3	No Sample	—	—	—
4	5588	46,000	2,500	1,200
5	5654	35,000	3,700	15,000
6	5708	48,000	3,900	18,000
7	5774	110,000	8,800	27,000
8	5828	30,000	4,700	3,600
9	5915	Broken in Transit	—	—
10	5971	37,000	4,000	5,500
11	6037	22,000	2,900	29,000
12	6102	41,000	3,100	3,200
Average		51,000	4,500	13,000

DATE	IMSO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 240.1 B				
Dec. 1	5433	64,000	4,100	2,800
2	5486	53,000	4,600	6,400
3	No Sample	—	—	—
4	5589	42,000	4,300	1,100
5	5655	31,000	2,300	11,000
6	5709	38,000	2,600	14,000
7	5775	120,000	9,700	42,000
8	5829	180,000	5,600	4,700
9	5916	45,000	4,600	7,200
10	5972	43,000	3,700	9,300
11	6038	25,000	4,100	7,700
12	6103	34,000	2,200	2,500
Average		62,000	4,400	9,900
Mississippi River M.P. 240.1 C				
Dec. 1	5434	53,000	2,800	2,600
2	5487	39,000	3,500	2,300
3	No Sample	—	—	—
4	5590	58,000	2,400	7,600
5	5656	32,000	2,500	8,900
6	5710	70,000	2,500	7,600
7	5776	60,000	5,000	19,000
8	5830	32,000	3,000	1,600
9	5917	44,000	3,700	5,600
10	5973	40,000	3,500	7,500
11	6039	28,000	3,400	9,300
12	6104	41,000	1,500	2,600
Average		45,000	1,800	6,800
Mississippi River M.P. 240.1 D				
Dec. 1	5435	59,000	2,000	320
2	5488	32,000	2,500	2,100
3	No Sample	—	—	—
4	5591	44,000	2,900	6,500
5	5657	41,000	2,100	4,100
6	5711	37,000	1,600	4,200
7	5778	36,000	2,400	6,500
8	5831	30,000	1,700	760
9	5918	52,000	3,400	4,800
10	5974	38,000	2,900	7,100
11	6040	23,000	3,500	6,800
12	6105	32,000	1,300	2,200
Average		39,000	2,400	4,100

DATE	LMSO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 140.1 E				
Dec. 1	5436	41,000	1,900	260
2	5489	28,000	520	1,400
3	No Sample	—	—	—
4	5592	58,000	2,100	4,100
5	5658	27,000	2,000	2,900
6	5712	52,000	2,200	3,700
7	No Sample	—	—	—
8	5832	24,000	1,600	450
9	5919	47,000	2,500	3,600
10	5975	42,000	2,000	3,300
11	6041	38,000	2,000	5,600
12	6106	56,000	930	2,100
Average		42,000	1,800	2,700
Mississippi River M.P. 118.8 A				
Dec. 1	**	35,000	1,900	560
2	5490	26,000	1,300	1,200
3	5540	43,000	2,400	5,900
4	5593	45,000	2,500	2,900
5	5567	38,000	2,100	9,000
6	5713	39,000	4,100	12,000
7	No Sample	—	—	—
8	5833	39,000	3,100	3,900
9	5928	33,000	3,200	4,900
10	5976	32,000	2,800	5,400
11	6050	27,000	3,400	12,000
12	6107	34,000	2,700	3,700
Average		36,000	2,700	5,600
Mississippi River M.P. 118.8 C				
Dec. 1	**	45,000	2,400	630
2	5491	24,000	3,300	4,700
3	5542	58,000	1,700	2,400
4	5594	45,000	3,700	21,000
5	5569	34,000	2,900	7,800
6	5714	33,000	2,700	13,000
7	5789	78,000	4,000	8,700
8	5834	81,000	2,300	4,300
9	5930	26,000	3,100	5,000
10	5977	31,000	2,200	4,100
11	6052	23,000	3,200	12,000
12	6103	38,000	3,900	4,100
Average		43,000	3,000	7,300

DATE	IMBO NO.*	COLIFORM/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 218.8 E				
Dec. 1	**	22,000	1,500	360
2	5492	58,000	2,600	4,500
3	5544	35,000	570	1,100
4	5595	41,000	2,000	3,300
5	5571	33,000	1,100	3,000
6	5715	33,000	1,500	3,200
7	5791	31,000	2,600	4,600
8	5835	39,000	2,500	2,600
9	5932	20,000	2,600	2,400
10	5978	41,000	2,400	3,000
11	6054	25,000	1,500	5,300
12	6109	26,000	2,300	3,300
Average		34,000	1,900	3,100
Kaskaskia River 4.50				
Dec. 1	**	3,500	370	50
2	**	2,400	270	48
3	**	2,600	270	150
4	5601	1,500	230	26
5	5583	1,600	220	28
6	5721	2,900	470	100
7	5803	5,200	1,200	3,900
8	5841	5,200	Est. 5,000	11,000
9	5944	11,000	2,600	6,400
10	5984	7,500	780	4,100
11	No Sample	—	--	--
12	No Sample	—	—	—
Average		43,000	1,100	2,600
Mississippi River M.P. 209.7 A				
Dec. 1	5456	43,000	1,500	530
2	**	44,000	1,500	2,900
3	5549	36,000	1,000	1,500
4	5596	26,000	1,300	6,700
5	5576	23,000	1,900	4,700
6	5716	35,000	1,600	6,800
7	5796	54,000	2,700	11,000
8	5836	44,000	3,300	15,000
9	5937	24,000	3,200	3,100
10	5979	35,000	2,400	4,800
11	6059	34,000	1,600	6,400
12	6110	36,000	1,500	3,500
Average		36,000	2,000	5,600

DATE	IMBO NO.*	COUNTS/100 ML		
		TOTAL COLIFORM	FECAL COLIFORM	FECAL STREPTOCOCCI
Mississippi River M.P. 109.7 C				
Dec. 1	5458	38,000	2,900	650
2	5494	49,000	1,800	2,800
3	5551	47,000	1,000	2,900
4	5597	25,000	1,700	4,100
5	5578	25,000	2,200	5,200
6	5517	20,000	1,600	7,800
7	5798	51,000	3,500	6,800
8	5837	42,000	3,400	7,200
9	5939	24,000	3,500	3,000
10	5930	33,000	2,000	3,100
11	6061	29,000	2,400	11,000
12	6111	43,000	2,400	3,800
Average		36,000	2,400	4,900
Mississippi River, M.P. 109.7 E				
Dec. 1	5460	32,000	1,400	350
2	5495	23,000	1,200	740
3	5553	12,000	760	110
4	5593	30,000	710	1,900
5	5580	32,000	1,600	2,600
6	5718	20,000	950	2,700
7	No Sample	—	—	—
8	5838	37,000	2,200	6,100
9	5941	12,000	1,700	3,300
10	5931	38,000	2,200	4,200
11	6063	52,000	1,400	3,800
12	6112	38,000	2,000	2,800
Average		30,000	1,500	2,600

*Lake Michigan Basin numbers were from sample tags.
**No number was on tag.

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